ANGLIA RUSKIN UNIVERSITY

FACULTY OF BUSINESS AND LAW

Understanding the factors impacting Clinicians' adoption of Mobile Health tools and their implications for organizational practices

A multiple-case study

A thesis in fulfilment of the requirements of Anglia Ruskin University

for the degree of Doctor of Philosophy

by Christine Jacob

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Abstract

Background: Mobile health (mHealth) have shown promise for their potential to enhance clinical workflows, improve patient access to care, and the quality of that care. However, there remain persistent barriers to adoption, and some users continue to resist the use of these new tools.

Objectives: This research investigated factors influencing clinicians' mHealth adoption, and expounded these and the potential implications for their workflow and quality of patient care.

Methods: A multiple-case study of three mHealth tools was conducted. Data were collected via 41 in-depth interviews with clinicians, technology providers, and medical informatics experts in 9 countries from April 2017 to March 2020. The case studies were examined in the context of relevant literature, identified by a systematic review that included171 studies published between 2008 and 2018.

Results: Findings confirmed that the use of mHealth can provide numerous benefits such as efficacy and time-saving, improved safety and quality of patient care, improved accessibility, and better data security and validation. They can also positively impact workflow through better transparency and collaboration, empowerment, and efficiency. However, the factors impacting adoption go beyond material features such as usefulness, ease of use, privacy and security, interoperability and costs. Social factors like clinicians' attitudes, awareness, experience, or culture are key. Organizational and policy factors are also vital and include user engagement, infrastructure, training, existing workload and resources, decision making, in addition to absence or ambiguity of regulations.

Conclusions: Factors impacting clinicians' adoption go beyond the material aspects of mHealth to also encompass substantial social and organizational elements. Therefore, from a practical perspective, mHealth providers should work together with clinicians and decision makers to address potential barriers and improve adoption. From a theoretical perspective, the study proposes an expansion of Leonardi's methodological guidance to better account for user engagement; and a consolidated framework that better factors in the complexity of healthcare's sociotechnical structure, and the interaction between the technical, social and organizational factors.

Keywords: eHealth; telemedicine; mHealth; workflow; sociomateriality; technology acceptance

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List of acronyms

AI: Artificial Intelligence

APEASE: Affordability, practicability, effectiveness, acceptability, safety/side effects and equity

CAQDAS: a computer assisted qualitative data analysis software

CASP: Critical Appraisal Skills Programme

CCIO: Clinical Information Officer

CFIR: The Consolidated Framework for Implementation Research

CHF: Congestive heart failure

CME: Continuing Medical Education

COPD: Chronic Obstructive Pulmonary Disease

DOI: theory of diffusion of innovation

DSRM: The Design Science Research Methodology

EHR: Electronic Health Record

EMR: Electronic Medical Record

EPR: Electronic Patient Record

mHealth: Mobile Health

NDA: non-disclosure agreement

PICO: participants, intervention, comparators, and outcome framework

PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines

RE-AIM: Reach, Effectiveness, Adoption, Implementation, and Maintenance framework

SE: Social Exchange theory

StEAM: The stakeholder empowered adoption model

TAM: Technology Acceptance Model

TAM2: An expanded version of the original Technology Acceptance Model

TF: Technological frames

TIB: Theory of Interpersonal Behaviour

TOE: The technology-organization-environment framework

TPB: Theory of Planned Behaviour

TR: Technology readiness

TRA: Theory of reasoned action

UTAUT: Unified Theory of Acceptance and Use of Technology

Copyright & related published work

The following papers have been published as a direct result of the research discussed in this thesis (please note that this is **not a PhD by published work** though):

Jacob C, Sanchez-Vazquez A, Ivory C. **Clinicians' Role in the Adoption of an Oncology Decision Support App in Europe and Its Implications for Organizational Practices: Qualitative Case Study**. JMIR Mhealth Uhealth 2019;7(5):e13555. DOI: 10.2196/13555

Jacob C, Sanchez-Vazquez A, Ivory C. **Social, Organizational, and Technological Factors Impacting Clinicians' Adoption of Mobile Health Tools: Systematic Literature Review**. JMIR Mhealth Uhealth 2020;8(2):e15935. DOI: 10.2196/15935

Jacob C, Sanchez-Vazquez A, Ivory C. **Understanding Clinicians' Adoption of Mobile Health Tools: A Qualitative Review of the Most Used Frameworks**. JMIR Mhealth Uhealth. 2020;8(7):e18072. DOI: 10.2196/18072

Jacob C, Sanchez-Vazquez A, Ivory C. **Factors impacting clinicians' adoption of a clinical photo documentation app and its implications for clinical workflows and quality of care - A qualitative case study.** JMIR Mhealth Uhealth 2020;8(9):e20203. DOI: 10.2196/20203

1 Introduction

Healthcare organizations are facing some global and persistent challenges such as rising costs, inconsistent care, and increasing burden of chronic disease. Public health policy makers increasingly believe that transforming care through a patient-centric design and taking a more preventive and proactive method that focuses not only on treating disease but mainly on life quality can be a way of overcoming the current challenges (Pavel et al., 2013). Mobile devices can play a significant role in this context. The latest improvements in technology have enabled mobile devices to accomplish some increasingly advanced tasks because of their very sophisticated sensors and features (Putzer and Park, 2010); so much so that a new type of healthcare tools: mobile health (mHealth), has appeared (Gagnon et al., 2016).

1.1 Research context

mHealth is a significant medical technology innovation; previous research has shown that it holds promise for cost savings, better access to healthcare, and improved quality of care (Armstrong et al., 2012; Avey and Hobbs, 2013; Anderson et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Mileski et al., 2017; Puszka et al., 2016). It can also support the transformation of healthcare and the shift towards a more patient-centric approach that doesn't solely focus on treating disease but also adopts a more predictive approach that can help prevent disease (Pavel et al., 2013; Payne, Wharrad and Watts, 2012). It has also been reported to contribute to decreasing clinicians' existing workload, and enhancing patient access to care (Kotronoulas et al., 2017b; Ruiz Morilla et al., 2017).

The increasing adoption of health apps has also contributed to addressing patients' information needs, and the myriad of information provided through these tools has helped make them feel more empowered (Kotronoulas et al., 2017a). Moreover, the data generated through mHealth can help practitioners personalize and adapt treatment plans correspondingly (Kotronoulas et al., 2018), resulting in a better quality of care via tailored treatments (Kotronoulas et al., 2018, 2017a). The structured and continuous data can help by prompting discussions of underreported and sensitive areas that can improve patient-clinician communications (Kotronoulas et al., 2018), and help make patients feel more taken-care-of (Kotronoulas et al., 2018). All these benefits encourage all patients, including older ones to adopt such apps (Bostrom et al., 2019) in defiance of the wide spread concept of a 'digital divide', and can boost patients' quality of life through personalized healthcare (Kotronoulas et al., 2018, 2017a).

It is, however, important to note that one of the key factors that differentiate mHealth from other Information and Communication Technology (ICT) tools is its user-driven nature, particularly, their availability, convenience and affordability (Akter and Ray, 2010); hence, a good understanding of the factors affecting user acceptance and adoption is vital to the success of these tools.

While previous studies indicate that practitioners generally have a favourable attitude towards mHealth, barriers to widespread adoption still persist (Connolly et al., 2020). For instance, the dynamic and liberal nature of the mHealth market makes the assessment of tools' quality very challenging; making clinicians' decision to choose which tool to adopt more difficult (Albrecht, Framke and von Jan, 2019). Moreover, the big data generated by these tools create a need for more comprehensive data privacy guidelines, particularly around the use of patient data that are clinically significant (Wernhart, Gahbauer and Haluza, 2019; Strotbaum et al., 2019). As well as existing workload, resource shortages, and essential workflow modifications were often raised as barriers to clinicians' adoption (Anderson et al., 2017; Ariens et al., 2017; Avey and Hobbs, 2013; Bhatta, Aryal and Ellingsen, 2015; Bagot et al., 2017; Brewster et al., 2014).

Many of the reported adoption factors go beyond the material features of technology to reflect the complexity of the healthcare context. Some of the barriers have slowed down the mHealth acceptance in certain healthcare settings (Kissi et al., 2019; Cowan et al., 2019), with some tools failing to advance beyond the pilot phase (Huang, Blaschke and Lucas, 2017), or failing to become a part of standard care (Boonstra and van Offenbeek, 2010; van Dyk, 2014). Also, practitioners sometimes have negative perceptions of mHealth impact on their autonomy and credibility (Brewster et al., 2014). Therefore, it is vital to shift our focus past technology's material features to address broader clinicians' concerns, such as clinical workflow enhancement, and workload problems (Newbould et al., 2019; Doak, Schwager and Hensel, 2020; Cowan et al., 2019).

These interconnected social, organizational, and technical factors, resulted in cases where users, predominantly clinicians, may resist mHealth adoption (Choi et al., 2018). This is especially relevant, considering that numerous studies, in developed and developing countries, indicated that clinicians' adoption is the most significant factor in the success of health technologies (Hussein, Rada, Khalifa, 2012; Moffatt and Eley, 2011; Walter and Lopez, 2008; Xue et al., 2015; Gagnon et al., 2012a). Thus, the necessity and importance, of a better grasp of the different factors influencing clinicians' adoption of mHealth in the complex healthcare context.

1.2 Research questions and definitions

Given that clinicians' resistance is one of the key challenges for mHealth adoption, it is important to better understand the reasons why clinicians adopt, or do not adopt healthcare technology, and how such adoption decisions could impact and be impacted by contextual factors such as organizational practices and healthcare policies.

Therefore, this research focuses on understanding the social and material factors impacting Clinicians' adoption of mHealth tools and their implications for organizational practices and health care policies. The topic is investigated through the following questions:

- What are the utilities and limitations of mHealth tools as perceived by clinicians?
- What are the factors that constrain or afford clinicians' adoption of mHealth?
- What are the organisational and policy factors and implications of this adoption?

In the context of this research, the World Health Organization's Global observatory of eHealth definition of mHealth was used. It considers it a sub-category of eHealth and defines it as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and other wireless devices", and it considers Telemedicine a sub-category of mHealth and defines it as "the communication or consultation between health professionals about patients using the voice, text, data, imaging, or video functions of a mobile device. But it can be applied to other situations; the management of chronic diseases of patients living at home is one example." (Kay, Santos and Takane, 2011).

And the Merriam-Webster dictionary's definition of the word 'clinician' was used: "a person qualified in the clinical practice of medicine, psychiatry, or psychology as distinguished from one specializing in laboratory or research techniques or in theory" (Merriam-Webster, 2008).

2 Literature review and theoretical framework

This thesis uses the sociotechnical theory as a guide, specifically, employing the three step process in Leonardi's methodological guidelines for the study of materiality and affordances (Leonardi, 2018). This section starts by explaining the logic behind choosing this theoretical framework, its context, and how it was used along the thesis; followed by a detailed and systematic review of the literature that was synthesised according to the theoretical framework by looking into technical, social, and organizational factors impacting clinicians' adoption of mHealth tools. Furthermore, to avoid the overreliance on a single line of thinking, in the third part of this section the researcher also analysed the most used frameworks for studying clinicians' adoption of mHealth tools and the factors that they encompass to ensure a more comprehensive thematic analysis. The section concludes with a summary and an aggregated view of the most used frameworks in studying mHealth adoption, identifying their gaps, and explaining how this research proposes to complement them.

2.1 Theoretical framework: the sociotechnical theory as a guide

User research investigating user choices, seeking a better understanding of how they interact with technology, and the relationship between work and technology was influenced by the appearance of the 'post-humanist' sociology of actor-network theory in the 1990s. This new turn proposed that users and new technologies are both equally regarded as 'actants' defined by a network of relationships, an idea that started to develop into what is currently known as sociomateriality, advocating for the notion that social and material aspects of technology adoption are inseparable (Orlikowski, 2007, 2009; Orlikowski and Scott, 2015). However, this lack of distinction between the users (social factors) and the technology (material and technical factors) from this ontological standpoint makes it challenging to explain user choices (Mutch, 2013; Leonardi, 2013; McPhee and Canary, 2013; Tunçalp, 2016).

Therefore, other scholars explain that, from their perspective, social and material aspects are not inseparable but rather 'imbricating' to produce steady socio-material constructions over time, ensuing certain actions (Leonardi and Rodriguez-Lluesma, 2013). Here, the social and the material are viewed as independent factors, where users interact with certain features of technology to create particular 'affordances' (Leonardi, 2018; Mutch, 2013; Leonardi, 2013; Carlile et al., 2013).

This active role of the user (social factors) in technology adoption implies that understanding the technology is being used is key for recognising how it influences organizations and the process of organizing work. Since the way people interact with technology and tools influences how they organize their micro-level relations (Garfinkel, 1967), and also impacts the definition of their roles (Goffman, 1956; Pinch, 2010). Furthermore, the increasing digitalization of organizations pushed scholars to investigate how the technologies used at the workplace are vital to the enablement of new forms of organizing work and practice (Bélanger and Watson-Manheim, 2006; Chudoba et al., 2005).

Consequently, to better comprehend clinicians' adoption (the users) of mHealth (new technologies) and the implications for healthcare organizations (organizing), the research themes and questions were developed in light of Leonardi's methodology and guidance "*Methodological Guidelines for the Study of Materiality and Affordances*" (2018) in order to crystallize the focus of the data collected in the interviews and subsequently the data analysis.

According to the guidance (Leonardi, 2018), a solid analysis of the factors impacting adoption and its impact on organizations follows three main steps:

- Step 1: Understanding and documenting the material aspects of technology and their limitations
- Step 2: Linking the material aspects of technology to the tasks that they enable and facilitate
- Step 3: Recognizing the processes resulting from these affordances and determining the consequential interactions taking place in the organization

The following sub-sections give an explanation of how the research analysis stemmed from these three steps by detailing the research themes and the logic behind them. The three steps are kept in the same order defined in the guidance to respect their cumulative nature, and to allow each step to lead us into the next one.

2.1.1 Step 1: 'Accounting for materials'

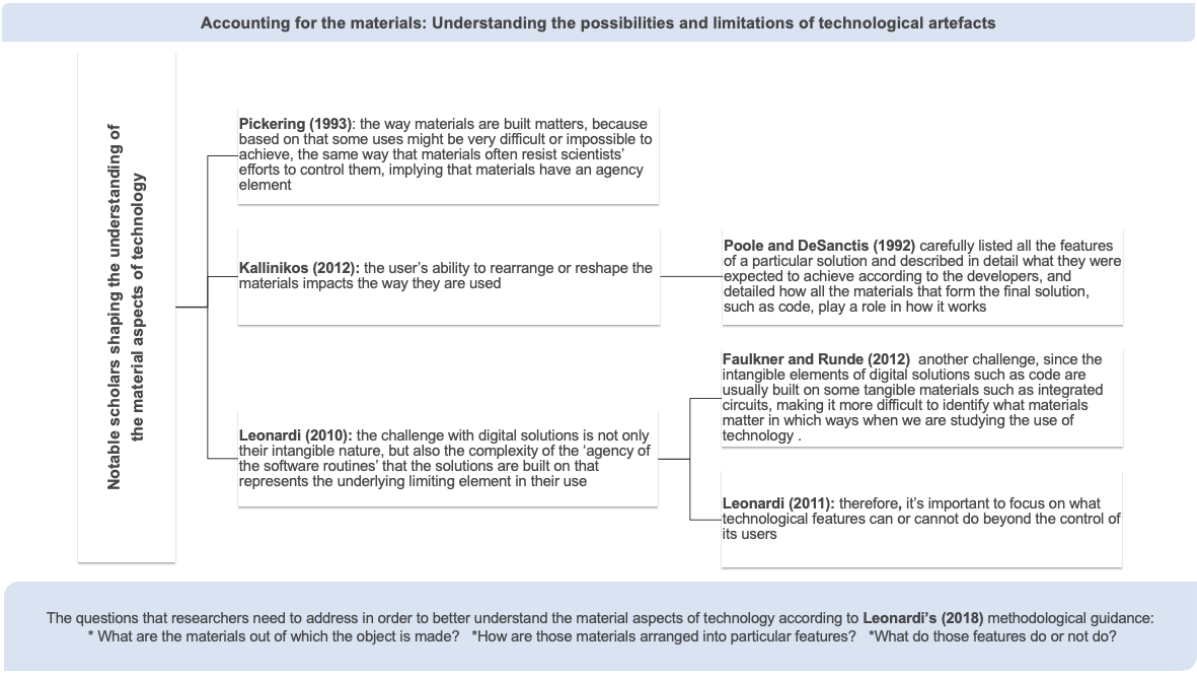
This step focuses on investigating the limitations of technology and the types of uses that it allows. Understanding the material aspects of mHealth tools is vital because it allows us to recognise the different ways they can be used as well as things that cannot be done with them due to material limitations in their features. Technological features '*can have various degrees of utility based on the forms into which they are cast*' (Leonardi, 2018, p.289), this

means that a good understanding of the technological features of the tool, recognizing what it can do versus what it cannot do, helps us understand not only the opportunities but also the limitations related to its use.

That explains why the way a technological tool is built and its specific features matter, because based on that some uses might be very difficult or impossible to achieve, the same way that the material factors sometimes resist scientists' efforts to control them, implying that materials have agency (Pickering, 1993). At the same time, the user's ability to reshape or rearrange the material aspects of a tool impacts the way it is used (Kallinikos, 2012). That explains why researchers desiring to study digital technological artefacts listed all the features of a particular tool and described in detail what they were expected to achieve according to the developers, and detailed how all the features that form the final solution play a role in how it works (Poole and DeSanctis, 1992). The intangible nature of digital tools and the complexity of the 'agency of the software routines' that they are built on, however, might sometimes pose a challenge in understanding the limitations of their use (Leonardi, 2010).

Based on these arguments, the methodological guidance suggests that studying the material aspects and features of technological tools are the first step that will help us then understand the role of materiality in the organizing process (Leonardi, 2018). Figure 1 shows a mind map, reflecting the ideas discussed in this sub-section, of the notable scholars that shaped the understanding of the material aspects of technology and led Leonardi to outline this step that revolves around three questions aiming to help us understand the materials that form a specific technological tool, how they are organized into specific features, and what such features do or not do. Answering these questions is key to recognizing the utilities and limitations of a specific mHealth tool.

Figure 1: Notable scholars shaping the understanding of the material aspects of technology



Source: Author after (Leonardi, 2018)

2.1.2 Step 2: 'Accounting for materiality'

This second step aims to understand users' perceptions of technology and how they intend to use it, because people's views of technology can impact the way they utilize it in their everyday life (Leonardi, 2018). Exploring this idea requires an important differentiation between two key terms in the literature: sociomateriality and materiality, and how the different scholars have portrayed the way materiality becomes 'entangled' with users' social practices. Inspired by agential realism (Barad, 2007) that theorizes the 'entanglement' of social and material aspects, sociomateriality is defined as:

"*The portmanteau 'sociomaterial' (no hyphen) attempts to signal [an] ontological fusion. Any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily entail each other in practice*." (Orlikowski and Scott, 2008, p.456)

However, this definition portrays a connection between the social and the material, which is only defined by researchers trying to make assertions about what counts or not from within a specific disciplinary view (Latour, 2005); this entails that sociomateriality as defined here is more of a way of being than a process that researchers can study (Leonardi, 2018). This concept of sociomateriality reminds us though that materials are continuously used, interpreted and shaped by users; technology is converted from a material object into a social

one when people start using it to achieve different tasks (Barley, 1981), it becomes part of their daily routine and the social and material aspects become imbricated (Leonardi, 2012), this is because materiality is triggered through users' interactions with it making it difficult to argue that the social and material aspects are fundamentally independent leading to Leonardi's differentiation between the concepts of sociomateriality and materiality:

"*So, if sociomateriality is an ontology, is there something out there called "sociomateriality" that we can also study empirically? I don't think so. Technological artefacts cannot have sociomateriality, but they can have materiality*" (Leonardi, 2018, p.284)

He explains that claiming that a certain technology has materiality means that its materials are being 'entangled' or 'imbricated' with users' experiences and culture in forms that make it hard to define the technological tool separately from its context of usage. Therefore, it is important to understand how materiality is produced by recognizing the constraints and affordances of technology to analyse materiality and the fusion of technology into social practices (Leonardi, 2018). This understanding acknowledges that users' intentions and the goals that they want to achieve when using a specific technology have an impact on its affordances.

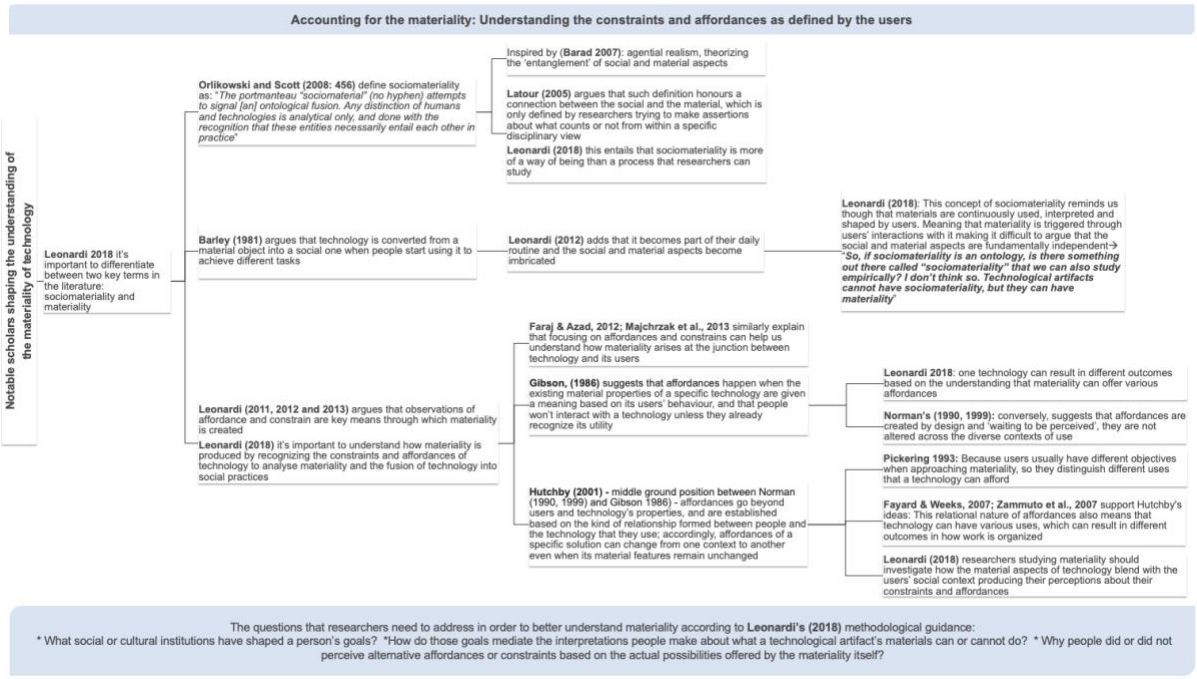
Several academics believe that materiality is typically created through the understanding of the affordances and constraints of a specific tool (Leonardi, 2011, 2012, 2013), such understanding can clarify how materiality occurs at the junction between technology and its users (Faraj and Azad, 2012; Majchrzak et al., 2013). Affordances might arise when the existing material features of a certain technological tool are given a meaning based on its users' perceptions and behaviour, bearing in mind that people typically will not interact with a technology unless they already recognize its utility (Gibson, 1986); this would entail that one technological tool might have different outcomes because materiality can offer various affordances depending on its users (Leonardi, 2018). Conversely, other scholars suggest that affordances are created by design and do not change depending on the contexts or users, but rather shaped by the designers and 'waiting to be perceived' or discovered by the users (Norman, 1990, 1999).

Hutchby (2001) takes a middle ground position between Norman (1990, 1999) and Gibson (1986) explaining that it is the relationship between the users and technology that results in specific affordances, meaning that affordances of a particular tool might change from one context to another even when its material features do not change (Hutchby, 2001). This is mainly due to the fact that users usually have different goals when approaching a tool (materiality), so they distinguish different uses that this tool can afford (Pickering, 1993). This

also means that technology can have different uses, resulting in various ways in how work is organized (Fayard and Weeks, 2007; Zammuto et al., 2007).

Based on these arguments, researchers studying materiality should investigate how the material aspects of technology blend with the users' social context producing their perceptions about their constraints and affordances (Leonardi, 2018). Figure 2 shows a mind map, reflecting the ideas discussed in this sub-section, of the notable scholars that shaped the understanding of the materiality of technology and led Leonardi to outline this step that revolves around three questions aiming to help us understand what social factors shape the users' objectives, how these objectives impact users' understandings of what a specific technology can or cannot do, and what makes users perceive different constraints or affordances based on the tool's features. Therefore, this step focuses on understanding users' views of mHealth, their usage intentions, decision drivers and what they perceive as an affordance or constraint for its adoption.

Figure 2: Notable scholars shaping the understanding of the materiality of technology



Source: Author after (Leonardi, 2018)

2.1.3 Step 3: 'Accounting for materialization'

The third and last step concentrates on how the material aspects of technology change the ways of organizing work and its process. After understanding the limitations of a technological tool, users' intentions for its use, and how this influences its affordances, it is

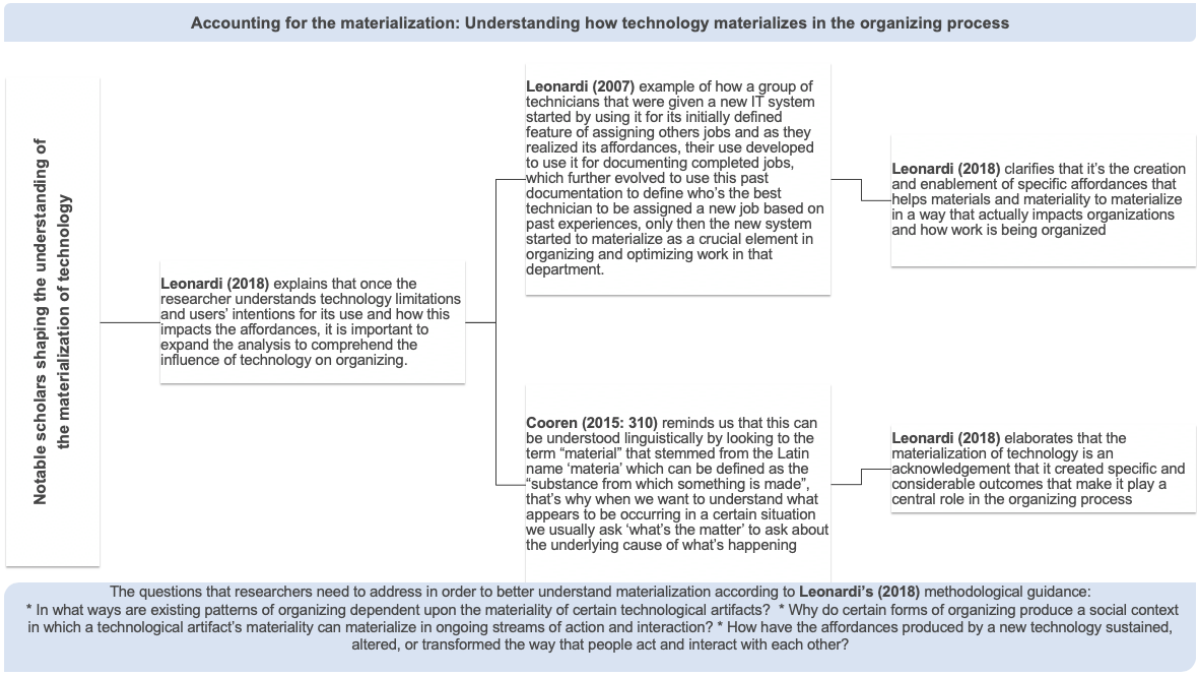
important to expand the analysis to comprehend the impact of technology adoption on the way people organize work. This step is about realizing the instances when particular affordances impact and transform users' actions, hierarchies and relationships that constitute the organizing process (Leonardi, 2018).

Not every technology will clearly impact the organizing process though, it is the enablement of certain affordances that helps a technological tool to materialize in a way that actually impacts how work is being organized in a specific organization (Leonardi, 2018). To better understand this idea, we can look at the example of a group of technicians who were given a new IT system; they started by using it for its initially defined feature of assigning jobs to others, and as they recognized its affordances, their use developed to use it for other uses such as documenting completed jobs, which further progressed to use this documentation to define who's the best technician to be assigned a new task based on their previous experiences. This is how the system started to materialize as a crucial element in organizing and optimizing work in that department rather than merely assigning jobs to others as initially intended (Leonardi, 2007).

The materialization of technology is an acknowledgement that it created specific and considerable outcomes that make it play a central role in the organizing process (Leonardi, 2018). This can be understood linguistically by looking to the term "material" that stemmed from the Latin name 'materia' that can be defined as the "substance from which something is made". Hence, when we want to understand what appears to be occurring in a certain situation we usually ask 'what's the matter' to ask about the underlying cause of what's happening (Cooren, 2015).

Based on these arguments, researchers studying materialisation should investigate how technology impacts the organizing process (Leonardi, 2018). Figure 3 shows a mind map, reflecting the ideas discussed in this sub-section, of the notable scholars that shaped the understanding of the materialization of technology and led Leonardi to outline this step that revolves around three questions aiming to help us understand how the current patterns of organizing rely on the materiality of specific technologies, why some organizing processes create a social context in which technology can materialize in actions and interactions' flows, and how have the affordances enabled by technology supported, changed, or transformed the way that people work or interact in a specific organization. Therefore, the focus in this final step is on understanding how mHealth impacts the way people interact and organize work and processes in healthcare organizations.

Figure 3: Notable scholars shaping the understanding of the materialization of technology



Source: Author after (Leonardi, 2018)

2.2 Systematic review of the literature

The literature review aimed to systematically examine the published literature to better understand the different factors that may impact clinicians' decision to adopt specific mHealth tools or not. Using Leonardi's (2018) methodological guidance explained in the previous section, it synthesized the current understanding about the factors impacting clinicians' adoption of mHealth not only from a technology perspective but also social and organizational perspectives. This sociotechnical approach was crucial for the researcher who had worked in the healthcare technology area for years and saw an overemphasis on the technical factors and aspects, therefore, she wanted to gain a more in-depth understanding of the complex and interrelated factors impacting technology adoption in healthcare by expanding her horizons using a sociotechnical approach that also takes individual, social, and organizational practices into account. The following sub-sections briefly summarize the methodology and high-level findings of the systematic review that was conducted in the context of this PhD thesis and published as:

Jacob C, Sanchez-Vazquez A, Ivory C. **Social, Organizational, and Technological Factors Impacting Clinicians' Adoption of Mobile Health Tools: Systematic Literature Review**. JMIR Mhealth Uhealth 2020;8(2):e15935. DOI: 10.2196/15935

2.2.1 Literature review methodology

The methods for this systematic literature review were drawn from the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) and the Cochrane Handbook (Higgins and Green, 2011), both of which offer guidelines towards a reliable and rigorous methodology. These methods were defined beforehand and the review protocol was published in the PROSPERO international prospective register of systematic reviews, available online (Jacob, Ivory and Sánchez-Vázquez, 2018). The analysis didn't necessitate any key deviation from the original protocol.

2.2.1.1 Purpose, scope, and definitions

The main purpose of the review was to examine the social, organizational and technological factors impacting clinicians' adoption of mHealth tools according to the published literature in a systematic manner. The scope was defined using the Participants, Intervention, Comparators, and Outcome (PICO) framework (PubMedHealth, 2018), and table 1 shows the corresponding inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria according to the PICO framework

Population (P)
Include: focused on healthcare professionals: e.g., physicians, nurses.
Exclude: focused only on patients, caregivers or technology providers.
Intervention (I)
Include: focused on solutions involving a smart device: e.g., Mobile Health apps, Telehealth.
Exclude: using other technologies: e.g., Virtual Reality, Machine Learning.
Comparators (C)
Does not apply.
Outcome (O)
Include: addresses factors impacting clinicians' adoption, acceptance, use, experience, implementation, usability, or attitude of using Mobile Health for health care service delivery, regardless of the condition.
Exclude: if focused only on mHealth success or development in general.
Publication type
Include: original, peer-reviewed, published paper.
Exclude: editorials, interviews, comments, unstructured observations, and position papers, or similar.

Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

To define mHealth, the researcher used the World Health Organization's Global observatory of eHealth definition as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and other wireless devices", Telemedicine is in turn a sub-category of mHealth and defined as "the communication or consultation between health professionals about patients using the voice, text, data, imaging, or video functions of a mobile device. But it can be applied to other situations; the management of chronic diseases of patients living at home is one example." (Kay, Santos and Takane, 2011). This is the same definition used in this thesis from start to end.

2.2.1.2 Outline of the search strategy

Three databases were searched to identify the relevant studies in August and September 2018: Medline PubMed, the Cochrane Library, and the SAGE database. The researcher narrowed the scope to articles published in the English language between January 2008 and August 2018. Hand searches of reference lists were not used because of the reasons summarized in the Cochrane Handbook: "positive studies are more likely to be cited" and "retrieving literature by scanning reference lists may thus produce a biased sample of studies" (Higgins and Green, 2011). Figure 4 shows the search string that was defined as per the Participants, Intervention, Comparators, and Outcome (PICO) framework (PubMedHealth, 2018) , there were no limitations on the types of health conditions qualified for inclusion and both qualitative and quantitative studies were included. As per the figure, the focus population for the study are clinicians, focus intervention are mHealth tools, focus outcome is the adoption of these tools; the search string included the possible synonyms or alternatives for each of the focus elements of the PICO framework.

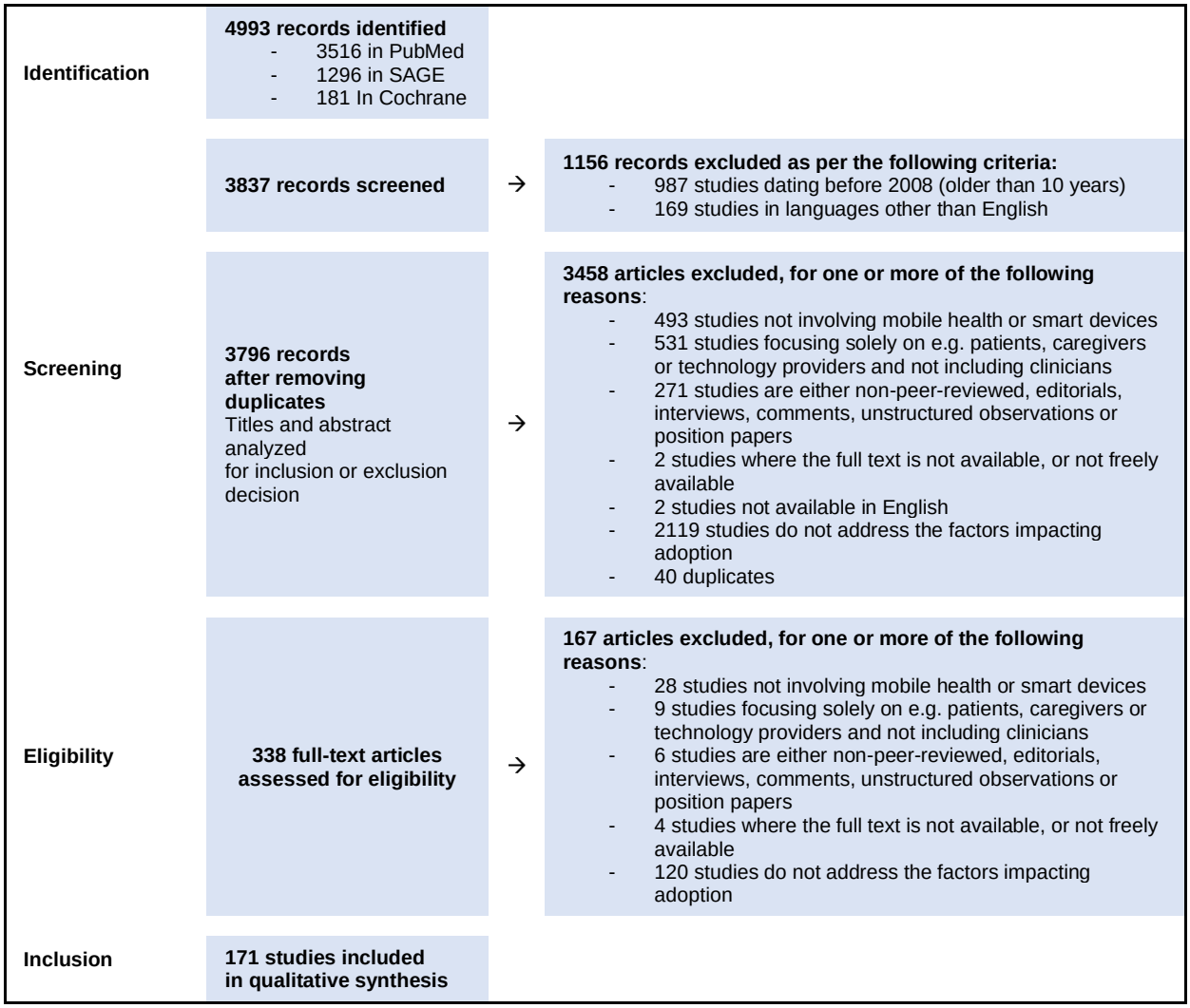
Figure 4: The search string according to the scope of the systematic literature

Participants (P): Clinicians	physician OR doctor OR nurse OR HCP OR "health care professional" OR oncologist OR clinician OR practitioner
	AND
Intervention (I): mHealth	mHealth OR "mobile health" OR telehealth OR eHealth OR "mobile applications" OR "mobile apps" OR smartphone OR telemonitoring OR app
	AND
Outcome (O): Adoption	Adoption OR Practice OR enable OR encourage OR foster OR acceptance OR use OR experience OR implementation OR usability OR attitude OR diffusion

Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

The databases' search using the defined search string yielded 4993 results, of which 171 met the inclusion criteria. Figure 5 shows the study selection flow diagram based on the PRISMA guidelines, clarifying the different levels of results starting with the identification phase, followed by the screening, then eligibility, and the inclusion results. As per the figure, the initial search yielded 4993 records, of which 3516 were identified in PubMed database, 1296 in SAGE database, and 181 In the Cochrane database. As a first step 1156 were excluded because they were either dated before 2008 (1156 studies), or written in a language other than English (169 studies), leaving 3837 records to screen. After the initial screening of the study abstracts, 3458 records were excluded either because they did not involve mobile health or smart devices (493 studies), were focussed solely on e.g., patients, caregivers or technology providers and did not include clinicians (531 studies), were either non-peer-reviewed, editorials, interviews, comments, unstructured observations or position papers (271 studies), the full text was not available (2 studies), were not available in English (2 studies), did not address the factors impacting adoption (2119 studies), or were duplicates (40 studies). This left 338 full text articles to be assessed for eligibility, of which 161 were excluded either because they did not involve mobile health or smart devices (28 studies), were focused solely on e.g., patients, caregivers or technology providers and did not include clinicians (9 studies), were either non-peer-reviewed, editorials, interviews, comments, unstructured observations or position papers (6 studies), the full text was not available (4 studies), or did not address the factors impacting adoption (120 studies). Therefore, this screening process resulted in 171 studies that met all the inclusion criteria and were therefore included in the qualitative synthesis.

Figure 5: Study selection flow diagram based on the PRISMA guidelines



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

2.2.1.3 Outline of critical appraisal strategy

The researcher used the Critical Appraisal Skills Programme (CASP) tool (Critical Appraisal Skills Programme, 2018) to assess the risk of study bias. The checklist and an Excel sheet with the appraisal of the included studies were both published in the paper that reports the detailed findings of the review as mentioned earlier (Jacob, Sanchez-Vazquez and Ivory, 2020a). In summary:

- 38/171 studies did not include a clear participant recruitment strategy
- 40/171 did not provide enough information on their data collection techniques
- 76/171 did not report on how they addressed potential ethical considerations
- 25/171 were not clear enough about their data analysis strategy

However, the researcher elected not to exclude articles based on their technical quality in order to capture both empirical and theoretical contributions from the published research.

2.2.2 Thematic approach according to the theoretical framework

The included studies encompassed a heterogeneous mixture of measures and outcomes that were not similar enough to allow a quantitative synthesis of the data. Thus, a narrative synthesis was used and structured around the different factors impacting clinician's adoption of mobile health solutions.

The researcher was most interested in gaining an in-depth understanding of the technical, social, and organizational factors impacting adoption, therefore, the data coding began with an initial data extraction grid that included themes based on the theoretical framework, Leonardi's "*Methodological Guidelines for the Study of Materiality and Affordances*" (Leonardi, 2018), as well as previous research and technology acceptance frameworks. Following Leonardi's (2018) guidance, the researcher categorized the relevant adoption factors into technical, social, and organizational factors. Additional themes were added as they emerged during the review process. Braun and Clarke's thematic analysis (Braun and Clarke, 2006) was used to identify and extract themes that met the review's scope and purpose.

2.2.3 Systematic review results

As detailed in section 2.2.1.2. the review included 171 studies that met the selection criteria. Table 2 shows the characteristics of the studies included in the systematic literature review, including: study design, sample size, sample composition, clinical specialty or health condition, and location for each of the included studies.

Table 2: Characteristics of the studies included in the systematic literature review

Study Design	Qualitative (n=64)	(Armstrong et al., 2011, 2012; Avey and Hobbs, 2013; Bagot et al., 2017; Beauregard, Arnaert and Ponzoni, 2017; Bello et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Carlisle and Warren, 2013; Cary et al., 2016; Casey, Shaw and Swinglehurst, 2017; Catan et al., 2015; Chiang et al., 2015; Chung et al., 2015; de Souza et al., 2017; de Vries et al., 2017; Egerton et al., 2017; Esterle and Mathieu-Fritz, 2013; Fairbrother et al., 2014; Farrell, 2016; Flynn et al., 2009; Giraldo et al., 2018; Goedken et al., 2017; Grünloh, Cajander and Myreteg, 2016; Han, Subramanian and Cameron, n.d.; Hanley et al., 2013; Hanna, May and Fairhurst, 2012; Hines et al., 2015; James et al., 2016; Jarvis-Selinger et al., 2011; Jimbo et al., 2013; Kayyali et al., 2017; Khan et al., 2015; Kim, Tiyyagura and Langhan, 2017;

		Kopanitsa and Yampolsky, 2016; Lacasta Tintorer et al., 2018; Levine et al., 2014; Lord et al., 2016; MacNeill et al., 2014; McNally, Frey and Crossan, 2017; Merchant et al., 2015; Moharra et al., 2015; Molfenter et al., 2015; Molleda et al., 2017; Moloczij et al., 2015; Morrow et al., 2017; Odeh et al., 2014; Öberg et al., 2017; Puszka et al., 2016; Rothstein et al., 2016; Sandberg et al., 2009; Schneider et al., 2016; Seto et al., 2012; Sharma, Barnett and Clarke, 2010; Sharma and Clarke, 2014; Sinclair et al., 2013; Sturesson and Groth, 2018; Taylor and Coates, 2015; van Gaalen et al., 2016; Varsi et al., 2015a; b; Vest et al., 2017; Wilhelmsen et al., 2014; Wynn et al., 2012; Zilliacus et al., 2010)
	Quantitative (n=58)	(Abd Ghani and Jaber, 2015; Adenuga, Iahad and Miskon, 2017; Albrecht et al., 2017; El Amrani et al., 2017; Anderson et al., 2017; Asua et al., 2012; Ayatollahi et al., 2018; Mandirola Brieux et al., 2017; Dünnebeil et al., 2012; Duhm et al., 2016; Duplaga, 2016; Gagnon et al., 2012b; Hackl et al., 2014; Hao and Padman, 2018; Holderried et al., 2018; Jefee-Bahloul, Duchen and Barkil-Oteo, 2016; Jetty et al., 2018; Jury, Walker and Kornberg, 2013; Kato et al., 2015; Kifle et al., 2010; Kim et al., 2016; Klack et al., 2013; Kleinpell et al., 2016; Koval, Kim and Makhlouf, n.d.; Kowitlawakul, 2011; Kuhn et al., 2014; Kuo et al., 2015; Lee et al., 2012; L'Esperance and Perry, 2016; Liu and Cheng, 2015; Ly et al., 2018; Mairesse et al., 2015; Miller et al., 2017; Moore et al., 2017; Ruiz Morilla et al., 2017; Moskowitz et al., 2010; O'Connor and Andrews, 2018; Okazaki et al., 2012; Orruño et al., 2011; Putzer and Park, 2012; Rho, Choi and Lee, 2014; Rogove et al., 2012; Sadoughi et al., 2017; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014; Sandholzer et al., 2015; Schmeer et al., 2016; Sezgin, Özkan-Yildirim and Yildirim, 2017; Sims et al., 2016; Smith and Buzi, 2014; Steinschaden, Petersson and Astrand, 2009; Uscher-Pines and Kahn, 2014; van Houwelingen et al., 2015; Villalba-Mora et al., 2015; Yaman et al., 2016; Zailani et al., 2014; Zhang, Cocosila and Archer, 2010)
	Mixed Methods (n=32)	(Alajlani and Clarke, 2013; Ariens et al., 2017; Bailey et al., 2017; Bidmead and Marshall, 2016; Bramley, Mangan and Conroy, 2018; Brown et al., 2018; Chang et al., 2017; Charani et al., 2013; Cox et al., 2011; Ehrler et al., 2018; Iacono et al., 2016; Jamu, Lowi-Jones and Mitchell, 2016; Jeon et al., 2014; Loh, Flicker and Horner, 2009; Lapão, da Silva and Gregório, 2017; Lygidakis et al., 2016; Mueller et al., 2014; Muigg et al., 2018; Nerminathan et al., 2017; Odnoletkova et al., 2016; Orchard et al., 2016; Payne, Weeks and Dunning, 2014; Possemato et al., 2017; Quanbeck et al., 2018; Ray et al., 2017; Shaw et al., 2013; Tahamtan et al., 2017; Taylor et al., 2016; Walker and Clendon, 2016; Williamson and Muckle, 2018; Zhang and Koch, 2015)
	Systematic Review (n=11)	(Brewster et al., 2014; Davis et al., 2014; Gagnon et al., 2016; Hickson et al., 2015; Koivunen and Saranto, 2018; Kumar, Merchant and Reynolds,

		2013; Lewis et al., 2012; Li and Cotton, 2018; Mileski et al., 2017; Penny, Bradford and Langbecker, 2018; Radhakrishnan et al., 2016)
	Others (n=5)	(Daniel et al., 2018; Choi et al., 2018; Jungwirth and Haluza, n.d.; Ahmad, Norman and O'Campo, 2012; Mishori et al., 2017)
Sample Size	Less than 10 (n=8)	(Beauregard, Arnaert and Ponzoni, 2017; Cary et al., 2016; Casey, Shaw and Swinglehurst, 2017; Molfenter et al., 2015; Odeh et al., 2014; Taylor et al., 2016; Varsi et al., 2015a; Vest et al., 2017)
	10 - 20 (n=41)	(Armstrong et al., 2011, 2012; Avey and Hobbs, 2013; Bagot et al., 2017; Bailey et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Brewster et al., 2014; Carlisle and Warren, 2013; Catan et al., 2015; Cox et al., 2011; Cunningham et al., 2013; Davis et al., 2014; de Souza et al., 2017; Duhm et al., 2016; Egerton et al., 2017; Ehrler et al., 2018; Esterle and Mathieu-Fritz, 2013; Farrell, 2016; Grünloh, Cajander and Myreteg, 2016; Hanna, May and Fairhurst, 2012; Hines et al., 2015; Jamu, Lowi-Jones and Mitchell, 2016; Khan et al., 2015; Kim, Tiyyagura and Langhan, 2017; Lord et al., 2016; Lapão, da Silva and Gregório, 2017; McNally, Frey and Crossan, 2017; Merchant et al., 2015; Mishori et al., 2017; Moharra et al., 2015; Molleda et al., 2017; Öberg et al., 2017; Sandberg et al., 2009; Sharma, Barnett and Clarke, 2010; Sharma and Clarke, 2014; Sturesson and Groth, 2018; Uscher-Pines and Kahn, 2014; Varsi et al., 2015b; Wilhelmsen et al., 2014; Wynn et al., 2012; Zilliacus et al., 2010)
	21 - 40 (n=30)	(Abd Ghani and Jaber, 2015; Bishop et al., 2013; Bramley, Mangan and Conroy, 2018; Chiang et al., 2015; Chung et al., 2015; Fairbrother et al., 2014; Gagnon et al., 2016; Giraldo et al., 2018; Goedken et al., 2017; Han, Subramanian and Cameron, n.d.; James et al., 2016; Jefee-Bahloul, Duchen and Barkil-Oteo, 2016; Jeon et al., 2014; Jimbo et al., 2013; Kayyali et al., 2017; Koval, Kim and Makhlouf, n.d.; Levine et al., 2014; MacNeill et al., 2014; Moloczij et al., 2015; Morrow et al., 2017; Payne, Weeks and Dunning, 2014; Possemato et al., 2017; Puszka et al., 2016; Rothstein et al., 2016; Sadoughi et al., 2017; Schmeer et al., 2016; Schneider et al., 2016; Seto et al., 2012; Sinclair et al., 2013; Walker and Clendon, 2016)
	41 - 60 (n=11)	(Ahmad, Norman and O'Campo, 2012; Anderson et al., 2017; Hanley et al., 2013; Iacono et al., 2016; Jarvis-Selinger et al., 2011; Kopanitsa and Yampolsky, 2016; Lacasta Tintorer et al., 2018; Loh, Flicker and Horner, 2009; Mairesse et al., 2015; van Gaalen et al., 2016; Zhang and Koch, 2015)
	61 - 80 (n=8)	(Bello et al., 2017; Bidmead and Marshall, 2016; de Vries et al., 2017; Jungwirth and Haluza, n.d.; Lee et al., 2012; L'Esperance and Perry, 2016; Putzer and Park, 2010; Sims et al., 2016)
	81 - 100 (n=5)	(Charani et al., 2013; Gagnon et al., 2012b; Muigg et al., 2018; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Zhang, Cocosila and Archer, 2010)
	More than 100 (n=61)	(Adenuga, Iahad and Miskon, 2017; Alajlani and Clarke, 2013; Albrecht et al., 2017; El Amrani et al., 2017; Ariens et al., 2017; Ayatollahi et al., 2018;

		Mandirola Brieux et al., 2017; Brown et al., 2018; Chang et al., 2017; Choi et al., 2018; Daniel et al., 2018; Dünnebeil et al., 2012; Duplaga, 2016; Flynn et al., 2009; Asua et al., 2012; Hackl et al., 2014; Hao and Padman, 2018; Holderried et al., 2018; Jetty et al., 2018; Jury, Walker and Kornberg, 2013; Kato et al., 2015; Kifle et al., 2010; Kim et al., 2016; Klack et al., 2013; Kleinpell et al., 2016; Kowitlawakul, 2011; Kuhn et al., 2014; Kuo et al., 2015; Liu and Cheng, 2015; Ly et al., 2018; Lygidakis et al., 2016; Miller et al., 2017; Moore et al., 2017; Ruiz Morilla et al., 2017; Moskowitz et al., 2010; Mueller et al., 2014; Nerminathan et al., 2017; O'Connor and Andrews, 2018; Odnoletkova et al., 2016; Okazaki et al., 2012; Orchard et al., 2016; Orruño et al., 2011; Putzer and Park, 2012; Quanbeck et al., 2018; Ray et al., 2017; Rho, Choi and Lee, 2014; Rogove et al., 2012; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014; Sandholzer et al., 2015; Sezgin, Özkan-Yildirim and Yildirim, 2017; Shaw et al., 2013; Smith and Buzi, 2014; Steinschaden, Petersson and Astrand, 2009; Tahamtan et al., 2017; Taylor and Coates, 2015; van Houwelingen et al., 2015; Villalba-Mora et al., 2015; Williamson and Muckle, 2018; Yaman et al., 2016; Zailani et al., 2014)
Sample Composition	Clinicians (physicians + nurses) (n=62)	(Adenuga, Iahad and Miskon, 2017; Asua et al., 2012; Ayatollahi et al., 2018; Mandirola Brieux et al., 2017; Cary et al., 2016; Charani et al., 2013; Chiang et al., 2015; Chung et al., 2015; Cox et al., 2011; Cunningham et al., 2013; Esterle and Mathieu-Fritz, 2013; Gagnon et al., 2012b, 2016; Goedken et al., 2017; Hackl et al., 2014; Han, Subramanian and Cameron, n.d.; Jamu, Lowi-Jones and Mitchell, 2016; Jefee-Bahloul, Duchen and Barkil-Oteo, 2016; Jimbo et al., 2013; Jungwirth and Haluza, n.d.; Kato et al., 2015; Kayyali et al., 2017; Khan et al., 2015; Kim et al., 2016; Koval, Kim and Makhlouf, n.d.; Kuhn et al., 2014; Kumar, Merchant and Reynolds, 2013; Levine et al., 2014; Lord et al., 2016; MacNeill et al., 2014; Mairesse et al., 2015; Merchant et al., 2015; Miller et al., 2017; Mishori et al., 2017; Moharra et al., 2015; Molfenter et al., 2015; Moloczij et al., 2015; Morrow et al., 2017; Mueller et al., 2014; Orchard et al., 2016; Orruño et al., 2011; Penny, Bradford and Langbecker, 2018; Puszka et al., 2016; Ray et al., 2017; Rogove et al., 2012; Rothstein et al., 2016; Sadoughi et al., 2017; Sandberg et al., 2009; Sharma, Barnett and Clarke, 2010; Sims et al., 2016; Sinclair et al., 2013; Smith and Buzi, 2014; Sturesson and Groth, 2018; Taylor et al., 2016; Uscher-Pines and Kahn, 2014; Varsi et al., 2015a; b; Wynn et al., 2012; Zailani et al., 2014; Zilliacus et al., 2010)
	Clinicians + others, e.g. patients (n=46)	(Ahmad, Norman and O'Campo, 2012; Alajlani and Clarke, 2013; Albrecht et al., 2017; Ariens et al., 2017; Avey and Hobbs, 2013; Bailey et al., 2017; Bello et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Bidmead and Marshall, 2016; Bishop et al., 2013; Bramley, Mangan and Conroy, 2018; Brown et al., 2018; Carlisle and Warren, 2013; Casey, Shaw and Swinglehurst, 2017; Catan et al., 2015; Chang et al., 2017; Choi et al., 2018; Davis et al., 2014; de Vries et al., 2017; Fairbrother et al., 2014; Flynn et al., 2009; Hanley et

		al., 2013; Hickson et al., 2015; Iacono et al., 2016; James et al., 2016; Jarvis-Selinger et al., 2011; Jeon et al., 2014; Jury, Walker and Kornberg, 2013; Kopanitsa and Yampolsky, 2016; Lacasta Tintorer et al., 2018; L'Esperance and Perry, 2016; Lewis et al., 2012; Loh, Flicker and Horner, 2009; Lapão, da Silva and Gregório, 2017; Lygidakis et al., 2016; Mileski et al., 2017; Molleda et al., 2017; Muigg et al., 2018; Odnoletkova et al., 2016; Possemato et al., 2017; Quanbeck et al., 2018; Radhakrishnan et al., 2016; Seto et al., 2012; Shaw et al., 2013; Taylor and Coates, 2015; van Gaalen et al., 2016)
	Physicians (n=41)	(Abd Ghani and Jaber, 2015; El Amrani et al., 2017; Anderson et al., 2017; Armstrong et al., 2011, 2012; Daniel et al., 2018; de Souza et al., 2017; Dünnebeil et al., 2012; Duhm et al., 2016; Egerton et al., 2017; Grünloh, Cajander and Myreteg, 2016; Hanna, May and Fairhurst, 2012; Hao and Padman, 2018; Hines et al., 2015; Holderried et al., 2018; Jetty et al., 2018; Kifle et al., 2010; Klack et al., 2013; Kuo et al., 2015; Lee et al., 2012; Liu and Cheng, 2015; Ly et al., 2018; Moore et al., 2017; Ruiz Morilla et al., 2017; Moskowitz et al., 2010; Nerminathan et al., 2017; Okazaki et al., 2012; Payne, Weeks and Dunning, 2014; Putzer and Park, 2012; Rho, Choi and Lee, 2014; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014; Sandholzer et al., 2015; Schneider et al., 2016; Sezgin, Özkan-Yildirim and Yildirim, 2017; Steinschaden, Petersson and Astrand, 2009; Tahamtan et al., 2017; Villalba-Mora et al., 2015; Wilhelmsen et al., 2014; Yaman et al., 2016; Zhang and Koch, 2015)
	Nurses (n=21)	(Beauregard, Arnaert and Ponzoni, 2017; Brewster et al., 2014; Duplaga, 2016; Ehrler et al., 2018; Farrell, 2016; Giraldo et al., 2018; Kleinpell et al., 2016; Koivunen and Saranto, 2018; Kowitlawakul, 2011; Li and Cotton, 2018; McNally, Frey and Crossan, 2017; O'Connor and Andrews, 2018; Odeh et al., 2014; Öberg et al., 2017; Putzer and Park, 2010; Schmeer et al., 2016; van Houwelingen et al., 2015; Vest et al., 2017; Walker and Clendon, 2016; Williamson and Muckle, 2018; Zhang, Cocosila and Archer, 2010)
Specialty/ Condition	Primary/acute care (n=17)	(Ahmad, Norman and O'Campo, 2012; Armstrong et al., 2012; Asua et al., 2012; Casey, Shaw and Swinglehurst, 2017; Davis et al., 2014; Farrell, 2016; Flynn et al., 2009; Hanley et al., 2013; Hickson et al., 2015; Jury, Walker and Kornberg, 2013; Lacasta Tintorer et al., 2018; Lewis et al., 2012; Molleda et al., 2017; Öberg et al., 2017; Rogove et al., 2012; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Shaw et al., 2013)
	COPD, CHF, and Cardiovascular disease (n=12)	(Brewster et al., 2014; Fairbrother et al., 2014; Gagnon et al., 2012b; Jarvis-Selinger et al., 2011; Kato et al., 2015; Klack et al., 2013; Mairesse et al., 2015; Odeh et al., 2014; Orchard et al., 2016; Seto et al., 2012; Sharma and Clarke, 2014; Taylor and Coates, 2015)

	Diabetes (n=10)	(Ayatollahi et al., 2018; Carlisle and Warren, 2013; de Vries et al., 2017; James et al., 2016; L'Esperance and Perry, 2016; Muigg et al., 2018; Odnoletkova et al., 2016; Okazaki et al., 2012; Sandberg et al., 2009; Vest et al., 2017)
	General and Family practice (n=9)	(Albrecht et al., 2017; El Amrani et al., 2017; Egerton et al., 2017; Hanna, May and Fairhurst, 2012; Jetty et al., 2018; Moore et al., 2017; Sandholzer et al., 2015; Wilhelmsen et al., 2014; Yaman et al., 2016)
	Psychology and Mental Health (n=8)	(Avey and Hobbs, 2013; Cunningham et al., 2013; Iacono et al., 2016; Kuhn et al., 2014; Possemato et al., 2017; Puszka et al., 2016; Sinclair et al., 2013; Wynn et al., 2012)
	Dermatology (n=4)	(Ariens et al., 2017; Armstrong et al., 2011, 2012; Orruño et al., 2011)
	Substance use recovery (n=4)	(Lord et al., 2016; Lygidakis et al., 2016; Molfenter et al., 2015; Quanbeck et al., 2018)
	Residential aged care, home health nursing (n=4)	(Loh, Flicker and Horner, 2009; Radhakrishnan et al., 2016; Taylor et al., 2016; Zhang, Cocosila and Archer, 2010)
	Pediatric, Maternal (n=4)	(Kim, Tiyyagura and Langhan, 2017; Ray et al., 2017; Rothstein et al., 2016; Uscher-Pines and Kahn, 2014)
	Neurology, Stroke (n=4)	(Duhm et al., 2016; Bramley, Mangan and Conroy, 2018; Moloczij et al., 2015; Moskowitz et al., 2010)
	ICU (n=4)	(Kleinpell et al., 2016; Kowitlawakul, 2011; Kumar, Merchant and Reynolds, 2013; Li and Cotton, 2018)
	Asthma (n=3)	(Morrow et al., 2017; Schneider et al., 2016; van Gaalen et al., 2016)
	Oncology (n=3)	(Cox et al., 2011; Jeon et al., 2014; Jimbo et al., 2013)
	Sexual Health, HIV (n=3)	(Bailey et al., 2017; Brown et al., 2018; Smith and Buzi, 2014)
	Others (n=13)	Ambulatory care (Dünnebeil et al., 2012), Cognitive behavioral therapy (Miller et al., 2017), Emergency (Mueller et al., 2014), Genetics (Zilliacus et al., 2010), Geriatrics (Esterle and Mathieu-Fritz, 2013; Levine et al., 2014), Hypertension (Mileski et al., 2017), Nephrology (Bello et al., 2017), Obesity and irritable bowel syndrome (Chung et al., 2015), Otolaryngology (Holderried et al., 2018), Radiology (Sadoughi et al., 2017), Speech-language pathology (Hines et al., 2015), Tuberculosis (Kopanitsa and Yampolsky, 2016)
Location	USA (n=38)	(Armstrong et al., 2011, 2012; Avey and Hobbs, 2013; Bishop et al., 2013; Cary et al., 2016; Chung et al., 2015; Cunningham et al., 2013; Goedken et al., 2017; Hao and Padman, 2018; Jetty et al., 2018; Jimbo et al., 2013;

		Kim, Tiyyagura and Langhan, 2017; Kleinpell et al., 2016; Koval, Kim and Makhlouf, n.d.; Kowitlawakul, 2011; Kuhn et al., 2014; Levine et al., 2014; Lord et al., 2016; Miller et al., 2017; Molfenter et al., 2015; Molleda et al., 2017; Moore et al., 2017; Moskowitz et al., 2010; Mueller et al., 2014; Possemato et al., 2017; Putzer and Park, 2012, 2010; Quanbeck et al., 2018; Ray et al., 2017; Sandberg et al., 2009; Schneider et al., 2016; Shaw et al., 2013; Sims et al., 2016; Smith and Buzi, 2014; Uscher-Pines and Kahn, 2014; Vest et al., 2017; Williamson and Muckle, 2018)
	UK (n=22)	(Bailey et al., 2017; Bidmead and Marshall, 2016; Bramley, Mangan and Conroy, 2018; Brewster et al., 2014; Casey, Shaw and Swinglehurst, 2017; Charani et al., 2013; Cox et al., 2011; Fairbrother et al., 2014; Flynn et al., 2009; Hanley et al., 2013; Hanna, May and Fairhurst, 2012; Jamu, Lowi-Jones and Mitchell, 2016; Kayyali et al., 2017; L'Esperance and Perry, 2016; MacNeill et al., 2014; Morrow et al., 2017; O'Connor and Andrews, 2018; Odeh et al., 2014; Payne, Weeks and Dunning, 2014; Sharma, Barnett and Clarke, 2010; Sharma and Clarke, 2014; Taylor and Coates, 2015)
	Australia (n=15)	(Carlisle and Warren, 2013; Egerton et al., 2017; Farrell, 2016; Hines et al., 2015; Iacono et al., 2016; James et al., 2016; Jury, Walker and Kornberg, 2013; Loh, Flicker and Horner, 2009; Moloczij et al., 2015; Nerminathan et al., 2017; Orchard et al., 2016; Puszka et al., 2016; Sinclair et al., 2013; Taylor et al., 2016; Zilliacus et al., 2010)
	Canada (n=9)	(Ahmad, Norman and O'Campo, 2012; Anderson et al., 2017; Beauregard, Arnaert and Ponzoni, 2017; Bello et al., 2017; Chang et al., 2017; Jarvis-Selinger et al., 2011; Jeon et al., 2014; Seto et al., 2012; Zhang, Cocosila and Archer, 2010)
	Germany (n=7)	(Albrecht et al., 2017; Dünnebeil et al., 2012; Duhm et al., 2016; Holderried et al., 2018; Klack et al., 2013; Sandholzer et al., 2015; Schmeer et al., 2016)
	Spain (n=7)	(Asua et al., 2012; Gagnon et al., 2012b; Lacasta Tintorer et al., 2018; Ruiz Morilla et al., 2017; Orruño et al., 2011; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Villalba-Mora et al., 2015)
	Norway (n=4)	(Varsi et al., 2015b; a; Wilhelmsen et al., 2014; Wynn et al., 2012)
	South Korea (n=4)	(Choi et al., 2018; Kim et al., 2016; Lee et al., 2012; Rho, Choi and Lee, 2014)
	Sweden (n=4)	(Grünloh, Cajander and Myreteg, 2016; Öberg et al., 2017; Sturesson and Groth, 2018; Zhang and Koch, 2015)
	Austria (n=3)	(Hackl et al., 2014; Jungwirth and Haluza, n.d.; Muigg et al., 2018)
	Iran (n=3)	(Ayatollahi et al., 2018; Sadoughi et al., 2017; Tahamtan et al., 2017)
	Netherlands (3)	(Ariens et al., 2017; van Gaalen et al., 2016; van Houwelingen et al., 2015)
	Taiwan (n=3)	(Chiang et al., 2015; Kuo et al., 2015; Liu and Cheng, 2015)

	Others (n=39)	Argentina (Giraldo et al., 2018), Australia-UK (Bagot et al., 2017), Austria-Sweden (Steinschaden, Petersson and Astrand, 2009), Bangladesh (Khan et al., 2015), Belgium (Odnoletkova et al., 2016), Brazil (de Souza et al., 2017), Congo (Mishori et al., 2017), Ethiopia (Kifle et al., 2010), Europe (Mairesse et al., 2015; Moharra et al., 2015), France (El Amrani et al., 2017; Esterle and Mathieu-Fritz, 2013), Ghana (Rothstein et al., 2016), Iraq (Abd Ghani and Jaber, 2015), Israel-Portugal (Catan et al., 2015), Italy (Lygidakis et al., 2016), Japan (Okazaki et al., 2012), Japan-Sweden (Kato et al., 2015), Jordan-Syria (Alajlani and Clarke, 2013), Lebanon (Daniel et al., 2018), Malaysia (Zailani et al., 2014), Nepal (Bhatta, Aryal and Ellingsen, 2015), Netherlands-Spain-UK (de Vries et al., 2017), New Zealand (McNally, Frey and Crossan, 2017; Walker and Clendon, 2016), Nigeria (Adenuga, Iahad and Miskon, 2017), North America-Europe (Rogove et al., 2012), Poland (Duplaga, 2016), Portugal (Lapão, da Silva and Gregório, 2017), Russia (Kopanitsa and Yampolsky, 2016), Senegal (Ly et al., 2018), South-North America (Mandirola Brieux et al., 2017), Spain-Colombia-Bolivia (Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014), Sri Lanka (Han, Subramanian and Cameron, n.d.), Switzerland (Ehrler et al., 2018), Syria (Jefee-Bahloul, Duchen and Barkil-Oteo, 2016), Turkey (Sezgin, Özkan-Yildirim and Yildirim, 2017; Yaman et al., 2016), US-South Africa-Thailand-Peru (Brown et al., 2018)

Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

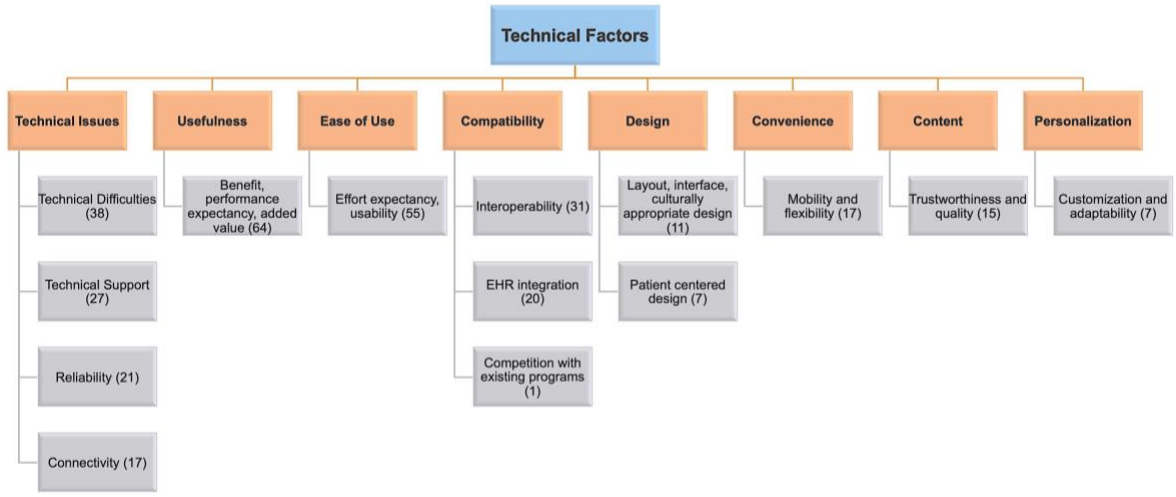
2.2.3.1 Technical and material factors

The technical and material factors impacting clinicians' mHealth adoption were categorized into 8 key themes: usefulness, ease of use, design, compatibility, technical issues, content, personalization and convenience; and these were sub-divided into 14 sub-themes. The most prominent factor group was technical issues, frequently linked to matters such as connectivity (17/171), system or tool reliability (21/171), the availability and efficacy of technical support (27/171), and technical difficulties in general (38/171). Factors defining usefulness, such as expected benefits, the tool's performance expectancy and its added value were also prominent (64/171); while factors determining ease of use such as the tool's usability and users' effort expectancy were also central (55/171) (Jacob, Sanchez-Vazquez and Ivory, 2020a).

Furthermore, some papers raised concerns related to the tools' compatibility such as interoperability issues (31/171), Electronic Health Record (EHR) integration (20/171), and the tool's competition with existing programs in the same clinic or hospital (1/171). Several design related aspects were also mentioned, such as the app's layout, interface, and whether the design is culturally appropriate (11/171); in addition to the importance of the

design to be patient centred (11/171). Convenience, often determined by the tool's level of mobility and flexibility also played a role (17/171), plus the trustworthiness and quality of the content (15/171), and personalization opportunities through the app's adaptability and customization (7/171) (Jacob, Sanchez-Vazquez and Ivory, 2020a). Figure 6 visualizes these technical and material factors, and their respective occurrence in the studied literature.

Figure 6: Technical and material factors and their occurrence in the studied literature

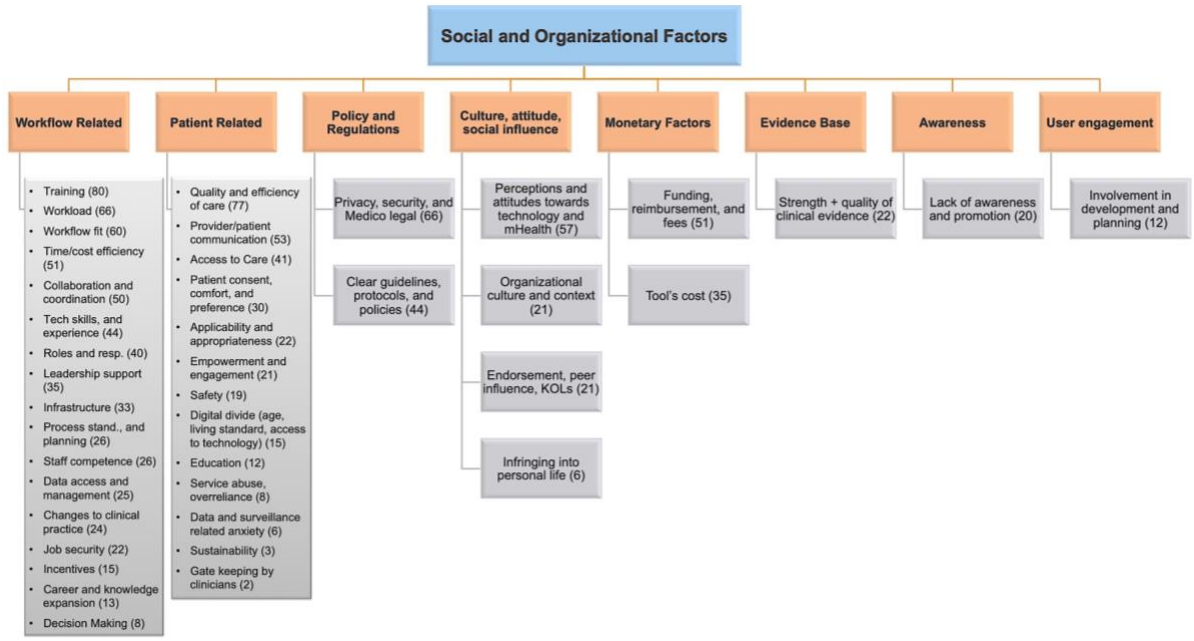


Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

2.2.3.2 Social and organizational factors

The social and organizational factors were noticeably more numerous than the technical factors and were also sorted in 8 main themes: workflow related factors, patient related factors, health care policy and regulations, local and organizational culture as well as attitude and social influence, monetary and cost factors, evidence base proving the value of the tool, users' awareness, and user engagement. These were in turn split into 41 sub-themes, as shown figure 7 and detailed in the following paragraphs.

Figure 7: Social and organizational factors and their occurrence in the studied literature



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

The workflow related factors were the most prominent in the included studies, with 17 sub-themes. Training (80/171), workload (66/171), workflow fit (60/171), time and cost efficiencies (51/171), collaboration and coordination among clinicians (50/171), users' technical skills and past experience (44/171), the impact of the tool's use on clinicians' roles and responsibilities (40/171), leadership support (35/171), the organizational or country level infrastructure (33/171), the standardization and planning of the clinical process (26/171), staff competence (26/171), health data access and management (25/171), potential changes to traditional clinical practice (24/171), job security of the care team (22/171), incentives (15/171), impact on clinicians' career and potential knowledge expansion (13/171), and decision making (8/171) (Jacob, Sanchez-Vazquez and Ivory, 2020a).

Patient related factors arose quite often, and were classified into 13 sub-themes. Quality and efficiency of patient care was the most prominent (77/171); followed by the quality and ease of communications between the care team and their patients (53/171), improving access to care (41/171), then the ease of getting an informed consent from the patients and their comfort with technology (30/171). Applicability and appropriateness, meaning the suitability of patients, based on their needs and characteristics arose frequently (24/171), and using mHealth to foster patient empowerment and engagement was also key (21/171). And in addition to patient safety (n=19); factors included: patient age, living standard, and access to technology (15/171); improved patient education (12/171), patient overdependence on the

support of their care team (8/171); also, patients' worries associated with their data interpretation, or their feeling of being observed (6/171). The least frequent factors were those echoing concerns regarding patients' long-term use (3/171), and protective attitudes of the practitioners (2/171) (Jacob, Sanchez-Vazquez and Ivory, 2020a).

Other social and organizational factors included the external healthcare policies and regulations related to data privacy, security, and medico-legal issues (66/171), and the need for clearer policies and guidelines (44/171). Cultural and social factors were also central and were mostly linked to users' attitudes towards technology (57/171), organizational culture and context (21/171), and peer influence and endorsement (21/171). Monetary factors such as reimbursement and funding (51/171), and cost (35/171) were also vital. Followed by the strength and quality of clinical evidence (22/171), lack of apps' promotion and users' awareness (20/171), and user involvement in the tools' development and planning (12/171) (Jacob, Sanchez-Vazquez and Ivory, 2020a).

2.2.4 Key findings: technical, social, and organizational factors

The detailed discussion of the systematic literature review findings were published earlier (Jacob, Sanchez-Vazquez and Ivory, 2020a), therefore, this section only summarizes the key overall outcomes of the review to put them in the context of this thesis. These findings will be discussed in contrast with the outcomes of this multiple-case study in the discussion section of this thesis.

2.2.4.1 Technological factors

The most cited technical barrier was the different types of technical difficulties and limitations, examples included issues like failing to update the system or difficulties with testing and installing the tools (Avey and Hobbs, 2013; Brewster et al., 2014; James et al., 2016), as well as poor video or audio quality (de Souza et al., 2017; Penny, Bradford and Langbecker, 2018; Sturesson and Groth, 2018; Zilliacus et al., 2010), and some log-in problems (Duhm et al., 2016; Farrell, 2016; Varsi et al., 2015b; Walker and Clendon, 2016). The availability and cooperation of technical support were also central; users reported concerns about technical service delivery due to shortage of technical support staff (Odeh et al., 2014; Öberg et al., 2017; Sharma and Clarke, 2014; Sharma, Barnett and Clarke, 2010; Wynn et al., 2012). System reliability is also key, as system failures and malfunctions may hinder adoption (Brown et al., 2018; Chiang et al., 2015; Steinschaden, Petersson and Astrand, 2009); clinicians want to be sure that a given mHealth tool will work in every

situation even when their patients are using the app on their own (Moloczij et al., 2015; Sharma, Barnett and Clarke, 2010).

Usefulness clearly impacts the adoption and intention to use too, users are more likely to use an app when they understand its benefits (Catan et al., 2015; Seto et al., 2012; Varsi et al., 2015b), and when it is useful for their work (Charani et al., 2013; Duhm et al., 2016; Putzer and Park, 2012; Sandholzer et al., 2015; Varsi et al., 2015a; Wilhelmsen et al., 2014; Zhang, Cocosila and Archer, 2010).Perceived usefulness is also frequently linked to the tool's ease of use and effort expectancy. Apps should be user friendly, so that every user can use them easily (Bhatta, Aryal and Ellingsen, 2015; Morrow et al., 2017; Penny, Bradford and Langbecker, 2018; Possemato et al., 2017; Puszka et al., 2016). Technical compatibility is also vital, clinicians prefer tools that integrate well with the other systems that they use in their daily work (Putzer and Park, 2012, 2010), and interoperability problems can raise user concerns (El Amrani et al., 2017; Bello et al., 2017). Equally, the lack of Electronic Medical Records (EMR) or EHR integration can cause similar issues (Davis et al., 2014; Gagnon et al., 2016), mainly because of the resulting limitations in data integration and exchange between the different systems (Bidmead and Marshall, 2016; Catan et al., 2015; Chung et al., 2015; Loh, Flicker and Horner, 2009), often resulting in duplication of effort and an unnecessary increase in workload (Morrow et al., 2017; Öberg et al., 2017; Sharma and Clarke, 2014).

Patient-centred and culturally appropriate design is also essential, cluttered and unorganized displays generally have a negative impact on user adoption (Jeon et al., 2014; Taylor and Coates, 2015; Taylor et al., 2016). Users should be able to adapt design elements according to their own preference (de Vries et al., 2017), to personalise the type of content according to their context and needs (Ehrler et al., 2018; O'Connor and Andrews, 2018), and to customise according to each patient's medical condition (Morrow et al., 2017; van Gaalen et al., 2016). Furthermore, the convenience and mobility of mHealth apps impact perceived usefulness and ease of use positively (Liu and Cheng, 2015), and can improve the timeliness of care services (Mileski et al., 2017; Seto et al., 2012), as the portability of such apps facilitate information access and tasks accomplishment (Nerminathan et al., 2017; Odnoletkova et al., 2016; Puszka et al., 2016; Sadoughi et al., 2017; Sezgin, Özkan-Yildirim and Yildirim, 2017). Conversely, the small size of the mobile screen can be perceived as an inconvenience by some users (Payne, Weeks and Dunning, 2014).

2.2.4.2 Social and organizational factors

The social and organizational factors impacting adoption were clearly more prominent in the included studies compared to the technical factors, highlighting the importance of taking the social and organizational contexts into account when studying adoption. This was a surprising as it was not anticipated that the social and organization factors would so vastly outnumber the technical ones.

2.2.4.2.1 Workflow related factors

Workflow related factors alone surprisingly included 17 sub-themes, and were the most prominent in the included studies, showing the importance of the implications of mHealth adoption for existing work practices. The availability of appropriate training programs is vital for adoption (Asua et al., 2012; Charani et al., 2013; Dünnebeil et al., 2012; Gagnon et al., 2016, 2012b); whereas insufficient training (Alajlani and Clarke, 2013; Bhatta, Aryal and Ellingsen, 2015; Brewster et al., 2014; Farrell, 2016; Öberg et al., 2017; Sharma and Clarke, 2014), the lack of time that must be invested in training (El Amrani et al., 2017; Davis et al., 2014; Sinclair et al., 2013; Wilhelmsen et al., 2014), the necessary resources to sustain training programs (Loh, Flicker and Horner, 2009; Puszka et al., 2016), and training programs that are purely technical do not address the workflow changes associated with the use of these new tools (Casey, Shaw and Swinglehurst, 2017; Cunningham et al., 2013; Giraldo et al., 2018; Kato et al., 2015; Penny, Bradford and Langbecker, 2018; Taylor and Coates, 2015) were among the most important barriers. Training-related factors are of significant importance mainly because users need to develop new skills in order to be able to profit from these tools and embed them well in their clinical practice (Bagot et al., 2017; Carlisle and Warren, 2013; Jamu, Lowi-Jones and Mitchell, 2016; Ruiz Morilla et al., 2017; Morrow et al., 2017; Schneider et al., 2016).

Resources availability and allocation were a key barrier (Ahmad, Norman and O'Campo, 2012; Ariens et al., 2017; Catan et al., 2015; Davis et al., 2014; Ehrler et al., 2018; Gagnon et al., 2016; James et al., 2016; Jetty et al., 2018; Kato et al., 2015; Kayyali et al., 2017; Morrow et al., 2017; Varsi et al., 2015a), as adequate staffing is considered a requirement for effective adoption (Avey and Hobbs, 2013; Carlisle and Warren, 2013; Koivunen and Saranto, 2018; Lord et al., 2016; Penny, Bradford and Langbecker, 2018; Schneider et al., 2016; Seto et al., 2012). Some papers recognized that mHealth triggered a surge in workload (Bhatta, Aryal and Ellingsen, 2015; Bishop et al., 2013; Fairbrother et al., 2014) mainly due to factors such as double data entry caused by lack of system integration (Chiang et al., 2015; Öberg et al., 2017; Walker and Clendon, 2016), adjusting to novel ways

of working (Hanley et al., 2013; Sharma, Barnett and Clarke, 2010; Sharma and Clarke, 2014), and poor workflow adaptability (Radhakrishnan et al., 2016). Users may refrain from adopting the tools entirely if they think that they would result in an increased workload (Bidmead and Marshall, 2016; de Souza et al., 2017; Mileski et al., 2017). Other studies, however, suggested that mHealth can also alleviate workload in cases where clinicians' recruitment and retention is challenging, through enhanced efficacy (Puszka et al., 2016), and support (Goedken et al., 2017; Koivunen and Saranto, 2018; Kumar, Merchant and Reynolds, 2013; Ruiz Morilla et al., 2017; Mueller et al., 2014).

Adoption also depends on the fit into the workflow and compatibility with the clinical practice (Bailey et al., 2017; Ehrler et al., 2018; Gagnon et al., 2016; Hickson et al., 2015; Lacasta Tintorer et al., 2018; Lee et al., 2012; Miller et al., 2017; Possemato et al., 2017; Sezgin, Özkan-Yildirim and Yildirim, 2017; van Gaalen et al., 2016); therefore, appropriate integration (Brewster et al., 2014; Choi et al., 2018; Radhakrishnan et al., 2016; Lord et al., 2016; Puszka et al., 2016), and an adept understanding of health care processes (Rho, Choi and Lee, 2014; Seto et al., 2012; Walker and Clendon, 2016) are indispensable to avoid potential disruption for clinical workflow. mHealth adoption can also result in workflow adjustments where a modification of working routines is necessary (Casey, Shaw and Swinglehurst, 2017; Chang et al., 2017; Molfenter et al., 2015), these changes are typically meant to complement standard clinical practice rather than replacing it (Cox et al., 2011; Morrow et al., 2017).

Facilitators included factors such as improved competitiveness through efficacies and optimized work patterns (Ariens et al., 2017; Armstrong et al., 2012, 2011; Bishop et al., 2013; Daniel et al., 2018; Kleinpell et al., 2016; Lacasta Tintorer et al., 2018; Li and Cotton, 2018; Nerminathan et al., 2017; Rothstein et al., 2016; Varsi et al., 2015b), better access to care (Mueller et al., 2014; Odnoletkova et al., 2016; Sims et al., 2016; Zilliacus et al., 2010), and quick identification of patients that need urgent care due to the timely feedback enabled by tools such as remote patient monitoring (Bello et al., 2017; Han, Subramanian and Cameron, n.d.; Jarvis-Selinger et al., 2011; Kim, Tiyyagura and Langhan, 2017; L'Esperance and Perry, 2016; Lapão, da Silva and Gregório, 2017; Mileski et al., 2017). However, the efficiencies resulting from mHealth use are sometimes compromised by a greater overall workload when there's no suitable reimbursement (Mairesse et al., 2015). Better multi-disciplinary collaboration and coordination may also encourage adoption (Ariens et al., 2017; Armstrong et al., 2012; Duhm et al., 2016; Jarvis-Selinger et al., 2011; Kleinpell et al., 2016; Kumar, Merchant and Reynolds, 2013; Molleda et al., 2017), as such tools facilitate peer support through second opinion and the novel models of shared decision making (Cary et

al., 2016; Esterle and Mathieu-Fritz, 2013; Iacono et al., 2016; Jetty et al., 2018; Kim, Tiyyagura and Langhan, 2017; Mueller et al., 2014; Penny, Bradford and Langbecker, 2018; Sims et al., 2016). Inversely, some papers stated that this can also result in more pressure on clinicians, as the additional coordination and communication with other staff members adds to their already high workload (Grünloh, Cajander and Myreteg, 2016), and as multi-disciplinary cooperation can be challenging (Varsi et al., 2015a) occasionally resulting in conflicting opinions or lack of trust (Li and Cotton, 2018; Moloczij et al., 2015).

Users familiarity with mHealth technology may generate confidence that may encourage adoption (Hanna, May and Fairhurst, 2012; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014; Sandholzer et al., 2015; Tahamtan et al., 2017; Zailani et al., 2014), while the lack of previous experience or poor technical skills may create uncertainties about how the tools work (Charani et al., 2013; de Souza et al., 2017; Hickson et al., 2015; Iacono et al., 2016; Jungwirth and Haluza, n.d.; Kayyali et al., 2017; Lacasta Tintorer et al., 2018; Molfenter et al., 2015; Putzer and Park, 2012; Sinclair et al., 2013; Villalba-Mora et al., 2015). Previous IT-related experience also lowered users' expected effort related to the use of these new tools, positively impacting their intention to use them (Dünnebeil et al., 2012; Duplaga, 2016; Gagnon et al., 2016; Rho, Choi and Lee, 2014).

Some changes in staff's roles and responsibilities are sometimes necessary to enable a smooth mHealth integration (Bagot et al., 2017; Khan et al., 2015; MacNeill et al., 2014; Molfenter et al., 2015; Öberg et al., 2017) , this could take the form of alignment of duties (Ariens et al., 2017; Hanley et al., 2013; Varsi et al., 2015b), redistribution of roles (Avey and Hobbs, 2013; Casey, Shaw and Swinglehurst, 2017), an expansion of job responsibilities (Varsi et al., 2015a), or even the creation of new functions to cover some of the new tasks connected to the management of the new technologies (Esterle and Mathieu-Fritz, 2013; Jury, Walker and Kornberg, 2013; Molleda et al., 2017; Odeh et al., 2014; Rothstein et al., 2016; Schneider et al., 2016; Sharma, Barnett and Clarke, 2010; Vest et al., 2017; Wynn et al., 2012). The new roles resulting from the use of mHealth can be related to data analysis and interpretation (Bramley, Mangan and Conroy, 2018; Levine et al., 2014; Rothstein et al., 2016), patient monitoring and triage (Quanbeck et al., 2018), in addition to some non-clinical tasks such as equipment installation and troubleshooting (Penny, Bradford and Langbecker, 2018; Sharma and Clarke, 2014; Sturesson and Groth, 2018).

Leadership support is also essential (Abd Ghani and Jaber, 2015; Ahmad, Norman and O'Campo, 2012; Gagnon et al., 2016; Li and Cotton, 2018; Lapão, da Silva and Gregório, 2017; Mileski et al., 2017; Putzer and Park, 2010, 2012; Radhakrishnan et al., 2016; Saigi-

Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Sandholzer et al., 2015), as it can facilitate potential organizational changes entailed by mHealth use, like roles and responsibilities (Esterle and Mathieu-Fritz, 2013), or workflow changes (Farrell, 2016; Öberg et al., 2017; Orchard et al., 2016), training and education (Kowitlawakul, 2011), and allocation of resources (Puszka et al., 2016; Sadoughi et al., 2017; Tahamtan et al., 2017). It can be challenging at times to get the required senior management support (Bidmead and Marshall, 2016; Catan et al., 2015; Smith and Buzi, 2014), mainly due to a lack understanding of mHealth (Chang et al., 2017), or a false perception that it would detract clinicians from their actual work (Loh, Flicker and Horner, 2009), which can result in a lack of recognition of staff's activities performed using these new tools (Lacasta Tintorer et al., 2018). Another precondition for mHealth success is the presence of a suitable organizational infrastructure (Bello et al., 2017; Charani et al., 2013; Liu and Cheng, 2015; Orruño et al., 2011; Zilliacus et al., 2010), including a reliable internet access, the availability of the necessary equipment, and a suitable space to perform the necessary tasks (Bailey et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Cary et al., 2016; Ehrler et al., 2018; Han, Subramanian and Cameron, n.d.; Iacono et al., 2016; James et al., 2016; Jamu, Lowi-Jones and Mitchell, 2016; Lewis et al., 2012; Moloczij et al., 2015; O'Connor and Andrews, 2018; Putzer and Park, 2012; Schneider et al., 2016; Shaw et al., 2013).

Implementation planning, and process standardization are also vital (Dünnebeil et al., 2012; Goedken et al., 2017; Puszka et al., 2016; Varsi et al., 2015b; Vest et al., 2017). Streamlined procedures (Egerton et al., 2017; Muigg et al., 2018; Sharma and Clarke, 2014), and clear protocols and guidelines (Esterle and Mathieu-Fritz, 2013; Koivunen and Saranto, 2018; Ray et al., 2017), are key for a successful adoption. A lack of such planning can result in workflow challenges that hinder adoption (Giraldo et al., 2018; Grünloh, Cajander and Myreteg, 2016; Jeon et al., 2014; Mileski et al., 2017; Molfenter et al., 2015; Penny, Bradford and Langbecker, 2018; Quanbeck et al., 2018; Sturesson and Groth, 2018; Taylor and Coates, 2015; van Gaalen et al., 2016). Furthermore, staff non-technical competence is also relevant (Avey and Hobbs, 2013; Koivunen and Saranto, 2018; Loh, Flicker and Horner, 2009; Orchard et al., 2016; Puszka et al., 2016; van Gaalen et al., 2016; Zilliacus et al., 2010); considerations such as familiarity with clinical terminology, a decent command of the language in which the tool is offered, and the capability to review and process the large amounts of data generated by mHealth tools are vital for successful adoption (Bhatta, Aryal and Ellingsen, 2015; Bramley, Mangan and Conroy, 2018; Chung et al., 2015; Kleinpell et al., 2016). Other skill related challenges can be the lack of confidence in the clinical

competence of other mHealth collaborators (James et al., 2016; Egerton et al., 2017); and the fear of showing knowledge gaps (Kifle et al., 2010; Klack et al., 2013; Sims et al., 2016).

Some data related issues such as information overload (Levine et al., 2014; MacNeill et al., 2014; Öberg et al., 2017), and data integration into the existing clinical workflow (Jimbo et al., 2013; Quanbeck et al., 2018; Radhakrishnan et al., 2016), can hinder adoption (Brown et al., 2018; James et al., 2016); especially because some of the available mHealth tools do not offer users the flexibility to tailor data reporting according to their individual needs (Chung et al., 2015; Davis et al., 2014; Miller et al., 2017). At the same time, availability and access to health care data (Duhm et al., 2016; Holderried et al., 2018; Moharra et al., 2015; Schneider et al., 2016), greater efficacy of data analysis (Klack et al., 2013; Rothstein et al., 2016), and improved quality of care resulting from the timely availability of data (L'Esperance and Perry, 2016; Lapão, da Silva and Gregório, 2017; Sandberg et al., 2009; Seto et al., 2012) can encourage adoption.

Clinical practice adjustments are sometimes necessary for a successful mHealth implementation (Ahmad, Norman and O'Campo, 2012; Bagot et al., 2017; Carlisle and Warren, 2013; Hanley et al., 2013; Kumar, Merchant and Reynolds, 2013; Lacasta Tintorer et al., 2018; Penny, Bradford and Langbecker, 2018), mainly due to the introduction of new paradigms such as patients' self-monitoring and reporting, which entail new care approaches (Brewster et al., 2014; Koivunen and Saranto, 2018; Odnoletkova et al., 2016; Öberg et al., 2017). Such changes can be challenging (Casey, Shaw and Swinglehurst, 2017; de Souza et al., 2017; Radhakrishnan et al., 2016); for example, clinicians can perceive mHealth as an interference with standard clinical practice when a tool allows patients to access their test results before their treating physician (Grünloh, Cajander and Myreteg, 2016). Additionally, clinicians' perceptions of the impact of such new tools on their autonomy and job security are also pertinent (Bramley, Mangan and Conroy, 2018; Brewster et al., 2014; Gagnon et al., 2016; Koivunen and Saranto, 2018; Li and Cotton, 2018; Öberg et al., 2017; Radhakrishnan et al., 2016); for example if they perceive that mHealth makes their patients' treatment plans and outcomes more accessible to others and accordingly more susceptible to external control or criticism, this may be a barrier to adoption (Li and Cotton, 2018; Liu and Cheng, 2015; MacNeill et al., 2014; Steinschaden, Petersson and Astrand, 2009; Uscher-Pines and Kahn, 2014; Kumar, Merchant and Reynolds, 2013; Rogove et al., 2012).

mHealth use can also positively impact clinicians' empowerment especially for nursing staff (MacNeill et al., 2014; Li and Cotton, 2018; O'Connor and Andrews, 2018; Odnoletkova et

al., 2016; Öberg et al., 2017; Penny, Bradford and Langbecker, 2018; Shaw et al., 2013), the educational benefits of these tools can encourage adoption (Nerminathan et al., 2017; Sims et al., 2016), as they are perceived as enablers that support clinical decisions, expand knowledge, and encourage best practices (Puszka et al., 2016; Rothstein et al., 2016; Sadoughi et al., 2017; Varsi et al., 2015b). Adoption can also be encouraged through proper incentives (Adenuga, Iahad and Miskon, 2017; Bhatta, Aryal and Ellingsen, 2015; Ruiz Morilla et al., 2017; Orchard et al., 2016; Vest et al., 2017). Financial incentives and better reimbursement schemes are not the only form of incentives though; awarding Continuing Medical Education (CME), adding the tools' use as a goal in the care team appraisals, and providing clarity around medico-legal issues may also increase adoption (Armstrong et al., 2011; Bello et al., 2017; Bramley, Mangan and Conroy, 2018; Jungwirth and Haluza, n.d.; Lacasta Tintorer et al., 2018; Lapão, da Silva and Gregório, 2017; Rho, Choi and Lee, 2014; Uscher-Pines and Kahn, 2014; Zhang and Koch, 2015).

The highly fragmented nature of the healthcare sector can result in decision making issues, especially in the absence of a dedicated accountable decision maker(s) for digital health programs in healthcare organizations (Bhatta, Aryal and Ellingsen, 2015; Jungwirth and Haluza, n.d.; Muigg et al., 2018; Jetty et al., 2018). This can also be a barrier when the official decision makers do not include clinicians in the selection and implementation of an mHealth tool (Flynn et al., 2009; Odeh et al., 2014; Öberg et al., 2017).

2.2.4.2.2 Patient related factors

Quality of care enhancements can encourage adoption (Anderson et al., 2017; Giraldo et al., 2018; Holderried et al., 2018; Jarvis-Selinger et al., 2011; Kim et al., 2016; Klack et al., 2013; Kleinpell et al., 2016; Kumar, Merchant and Reynolds, 2013; Lord et al., 2016; McNally, Frey and Crossan, 2017; Merchant et al., 2015; Mileski et al., 2017; Moharra et al., 2015; Miller et al., 2017; Moloczij et al., 2015; Ruiz Morilla et al., 2017; Okazaki et al., 2012; Possemato et al., 2017; Putzer and Park, 2010, 2012; Radhakrishnan et al., 2016; Ray et al., 2017; Steinschaden, Petersson and Astrand, 2009; Taylor and Coates, 2015; Varsi et al., 2015b; Zhang and Koch, 2015), such improvements are typically the result of enhanced information access, better disease control, tailored treatment plans, and more proactive patient care (Bidmead and Marshall, 2016; Avey and Hobbs, 2013; Carlisle and Warren, 2013; Cary et al., 2016; Chung et al., 2015; Daniel et al., 2018; de Souza et al., 2017; Esterle and Mathieu-Fritz, 2013; Farrell, 2016; Han, Subramanian and Cameron, n.d.; Hanley et al., 2013; Hickson et al., 2015; Jury, Walker and Kornberg, 2013; Kayyali et al., 2017; Khan et al., 2015; Kim, Tiyyagura and Langhan, 2017; Lee et al., 2012; L'Esperance

and Perry, 2016; Li and Cotton, 2018; Lapão, da Silva and Gregório, 2017; Mairesse et al., 2015; Mueller et al., 2014; Muigg et al., 2018; Odnoletkova et al., 2016; Öberg et al., 2017; Rogove et al., 2012; Seto et al., 2012; Sharma and Clarke, 2014; Vest et al., 2017). However, some practitioners raised concerns about the quality of patient self-reporting, the risk of overtreatment, or the reporting of false positives (Davis et al., 2014; de Vries et al., 2017). The desire for a better patient-clinician communication may also encourage adoption (El Amrani et al., 2017; Bailey et al., 2017; Bishop et al., 2013; Han, Subramanian and Cameron, n.d.; Koivunen and Saranto, 2018; Vest et al., 2017), this is in cases where the tool improves communication (Anderson et al., 2017; Bidmead and Marshall, 2016; Duhm et al., 2016; Hines et al., 2015; Kopanitsa and Yampolsky, 2016; Lacasta Tintorer et al., 2018; L'Esperance and Perry, 2016; Mileski et al., 2017; Moharra et al., 2015; Molfenter et al., 2015; Penny, Bradford and Langbecker, 2018; Radhakrishnan et al., 2016; Sandberg et al., 2009; Schneider et al., 2016; Seto et al., 2012; Sturesson and Groth, 2018; Walker and Clendon, 2016; Zhang and Koch, 2015), however, it can be a barrier when practitioners perceive the tool as an hindrance to their communications with their patients (Brewster et al., 2014; Cox et al., 2011; Flynn et al., 2009; Grünloh, Cajander and Myreteg, 2016; Kayyali et al., 2017; Wilhelmsen et al., 2014). Communications related concerns are mainly about loss of human interaction, potential privacy breaches, medico legal matters, unprofessional image, and risks of patient's overreliance on the tool (Daniel et al., 2018; Fairbrother et al., 2014; Loh, Flicker and Horner, 2009; Muigg et al., 2018; Öberg et al., 2017; Sharma, Barnett and Clarke, 2010; Sharma and Clarke, 2014; Wynn et al., 2012).

Improving access to care is another facilitator (Anderson et al., 2017; Armstrong et al., 2012; Bidmead and Marshall, 2016; Choi et al., 2018; Daniel et al., 2018; Flynn et al., 2009; Hickson et al., 2015; Loh, Flicker and Horner, 2009; Merchant et al., 2015; Mileski et al., 2017; Odnoletkova et al., 2016; Puszka et al., 2016; Radhakrishnan et al., 2016; Rho, Choi and Lee, 2014; Rogove et al., 2012; Sturesson and Groth, 2018), especially when mHealth allows healthcare access to underserved patients (Armstrong et al., 2011; Bhatta, Aryal and Ellingsen, 2015; Cary et al., 2016; Catan et al., 2015; Chang et al., 2017; Cunningham et al., 2013; Egerton et al., 2017; Han, Subramanian and Cameron, n.d.; Jetty et al., 2018; Kayyali et al., 2017; Molfenter et al., 2015; Moskowitz et al., 2010; Mueller et al., 2014; Sandberg et al., 2009; Sinclair et al., 2013). Digital tools may enhance access by reducing or even eliminating travel costs (Avey and Hobbs, 2013; Bhatta, Aryal and Ellingsen, 2015; Bishop et al., 2013; Levine et al., 2014; Lewis et al., 2012; MacNeill et al., 2014; Seto et al., 2012; Shaw et al., 2013; Zilliacus et al., 2010). Also, patient preferences, comfort, and consent play a central role in adoption (Ahmad, Norman and O'Campo, 2012; Avey and Hobbs,

2013; Egerton et al., 2017; Gagnon et al., 2016; Hanna, May and Fairhurst, 2012; Iacono et al., 2016; Kato et al., 2015; Koivunen and Saranto, 2018; Ruiz Morilla et al., 2017; Moskowitz et al., 2010; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Wynn et al., 2012), these preferences are influenced by several elements such as patients' age, the complexity of their health condition, technical skills, access to technology, or data privacy concerns (Armstrong et al., 2012; Bidmead and Marshall, 2016; Bishop et al., 2013; Bramley, Mangan and Conroy, 2018; Cox et al., 2011; Flynn et al., 2009; Hickson et al., 2015; Jarvis-Selinger et al., 2011; Jimbo et al., 2013; Jungwirth and Haluza, n.d.; Levine et al., 2014). Additionally, practitioners believe that these tools may not be suitable to all patients (Gagnon et al., 2016; Jury, Walker and Kornberg, 2013; Lord et al., 2016; Molleda et al., 2017; Penny, Bradford and Langbecker, 2018; Vest et al., 2017; Wynn et al., 2012; Zilliacus et al., 2010), therefore, the presence of a clear selection criteria is very important (Odeh et al., 2014; Odnoletkova et al., 2016; Radhakrishnan et al., 2016; Sharma, Barnett and Clarke, 2010; Wilhelmsen et al., 2014). Conversely, some clinicians believe that mHealth is more suitable for chronic patients, or those with an unstable health conditions because they require more attention (Fairbrother et al., 2014; Moharra et al., 2015); while others believed it is not appropriate for severely ill patients, or those with health impairments (Kato et al., 2015; Koivunen and Saranto, 2018; MacNeill et al., 2014; Puszka et al., 2016; Sandberg et al., 2009; Sinclair et al., 2013; Varsi et al., 2015b).

Tools that promote patient engagement and empowerment, offering them more autonomy and assurance about their health condition are more likely to be adopted (Catan et al., 2015; Cox et al., 2011; Giraldo et al., 2018; Hanley et al., 2013; L'Esperance and Perry, 2016; Lapão, da Silva and Gregório, 2017; MacNeill et al., 2014; Mileski et al., 2017; Possemato et al., 2017; Puszka et al., 2016; Schneider et al., 2016; Seto et al., 2012; Vest et al., 2017; Wilhelmsen et al., 2014; Zhang and Koch, 2015). Similarly, mHealth tools that enhance patient safety through early symptom detection, timely reporting, and structured documentation are more accepted by clinicians (Bishop et al., 2013; Bramley, Mangan and Conroy, 2018; Giraldo et al., 2018; Kleinpell et al., 2016; Li and Cotton, 2018; Moharra et al., 2015; Penny, Bradford and Langbecker, 2018; Seto et al., 2012; Steinschaden, Petersson and Astrand, 2009; Varsi et al., 2015b). However, practitioners are concerned about the digital divide, and those patients that might be marginalized because their lack of technology access or skills, those who have literacy problems, or a lower living standard (Hanna, May and Fairhurst, 2012; Jimbo et al., 2013; Jungwirth and Haluza, n.d.; Kayyali et al., 2017; Koivunen and Saranto, 2018; Levine et al., 2014; Miller et al., 2017; Moskowitz et al., 2010;

Puszka et al., 2016; Sandberg et al., 2009; Sharma, Barnett and Clarke, 2010; Sinclair et al., 2013; Smith and Buzi, 2014; van Gaalen et al., 2016).

Adoption is also positively impacted by tools that improve patient awareness and education (Daniel et al., 2018; Davis et al., 2014; Jarvis-Selinger et al., 2011; Jimbo et al., 2013; Levine et al., 2014; Odnoletkova et al., 2016; Orchard et al., 2016; Ray et al., 2017; Sandberg et al., 2009; Oudshoorn, Rommes and Stienstra, 2004; Varsi et al., 2015b; Vest et al., 2017); but some practitioners' fear that the convenience of mHealth might raise the risk of patients' overreliance on their care team's support (Anderson et al., 2017; Fairbrother et al., 2014; Radhakrishnan et al., 2016; Seto et al., 2012), and that they may over-utilize the tool or attempt to contact their treating practitioner after hours (Loh, Flicker and Horner, 2009; Shaw et al., 2013). However, surveillance and data related anxiety may be a barrier to adoption (Daniel et al., 2018; Steinschaden, Petersson and Astrand, 2009), especially in cases where patients might get extremely anxious or overwhelmed by the vast amounts of data offered through these tools (El Amrani et al., 2017; Grünloh, Cajander and Myreteg, 2016), or might feel constantly watched due to their use of digital patient monitoring tools (MacNeill et al., 2014; Seto et al., 2012).

2.2.4.2.3 Other social and organizational factors

There were also some other social and organizational factors impacting mHealth adoption. Fears related to health data privacy and security issues may hinder clinicians' adoption (Abd Ghani and Jaber, 2015; Ahmad, Norman and O'Campo, 2012; Albrecht et al., 2017; Bidmead and Marshall, 2016; Brown et al., 2018; Egerton et al., 2017; Gagnon et al., 2016; Jungwirth and Haluza, n.d.; Klack et al., 2013; Koivunen and Saranto, 2018; Lygidakis et al., 2016; Molfenter et al., 2015; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; van Gaalen et al., 2016; Villalba-Mora et al., 2015). The main data-related barriers were the potential medico-legal risks, healthcare data anonymity, and risks of inappropriate data use(El Amrani et al., 2017; Anderson et al., 2017; Ariens et al., 2017; Avey and Hobbs, 2013; Bailey et al., 2017; Brewster et al., 2014; Chang et al., 2017; Davis et al., 2014; de Souza et al., 2017; Hackl et al., 2014; Han, Subramanian and Cameron, n.d.; Hanna, May and Fairhurst, 2012; Hickson et al., 2015; Holderried et al., 2018; Jarvis-Selinger et al., 2011; Jetty et al., 2018; Jimbo et al., 2013; Koval, Kim and Makhlouf, n.d.; Lacasta Tintorer et al., 2018; Mishori et al., 2017; Moskowitz et al., 2010; Muigg et al., 2018; Penny, Bradford and Langbecker, 2018; Quanbeck et al., 2018; Radhakrishnan et al., 2016; Rogove et al., 2012). Remarkably, some papers concluded that concerns related to data privacy are necessarily a barrier to adoption, and that some practitioners might still intend to use

mHealth tools despite their privacy concerns (Dünnebeil et al., 2012; Okazaki et al., 2012; van Houwelingen et al., 2015). Additionally, healthcare policy and regulations related to reimbursement, malpractice protection, credentialing, and licensing can definitely impact adoption (Abd Ghani and Jaber, 2015; Alajlani and Clarke, 2013; Brewster et al., 2014; de Souza et al., 2017; Gagnon et al., 2016; Lord et al., 2016; Moore et al., 2017; Moskowitz et al., 2010; Puszka et al., 2016; Rogove et al., 2012; Uscher-Pines and Kahn, 2014). Factors such as incompatible regulations (Charani et al., 2013; Chiang et al., 2015; Jeon et al., 2014; McNally, Frey and Crossan, 2017; Mileski et al., 2017; Mueller et al., 2014), restraining directives (Jetty et al., 2018; Merchant et al., 2015), absence of suitable health policies and clinical protocols (Catan et al., 2015; Han, Subramanian and Cameron, n.d.; James et al., 2016; Kato et al., 2015; Molfenter et al., 2015; Nerminathan et al., 2017; Odnoletkova et al., 2016), can negatively impact adoption.

Clinicians' attitudes towards technology in general (Chiang et al., 2015; Kim et al., 2016; Ly et al., 2018; Mileski et al., 2017; Moloczij et al., 2015; Putzer and Park, 2012; Sandholzer et al., 2015; Sezgin, Özkan-Yildirim and Yildirim, 2017; Smith and Buzi, 2014; Williamson and Muckle, 2018) or mHealth specifically (Abd Ghani and Jaber, 2015; Ayatollahi et al., 2018; Brewster et al., 2014; Chang et al., 2017; Kleinpell et al., 2016; Koivunen and Saranto, 2018; Kowitlawakul, 2011; Li and Cotton, 2018; Rogove et al., 2012; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014) may also impact adoption. Users who are resistant to change or unfamiliar with mobile technologies may refrain from using health apps (Albrecht et al., 2017; Bidmead and Marshall, 2016; Bishop et al., 2013; Catan et al., 2015; Klack et al., 2013; Kumar, Merchant and Reynolds, 2013; Levine et al., 2014; Molfenter et al., 2015; Varsi et al., 2015a). Some negative cultural views on mobile use at work can also be a barrier (Daniel et al., 2018; McNally, Frey and Crossan, 2017; O'Connor and Andrews, 2018), as well as some individual traits such as the person's degree of adaptability and the willingness to try new things (Holderried et al., 2018; Lacasta Tintorer et al., 2018; Lapão, da Silva and Gregório, 2017). Other social factors such as endorsement and peer influence may influence adoption (Avey and Hobbs, 2013; Gagnon et al., 2016; Okazaki et al., 2012; Putzer and Park, 2010; Radhakrishnan et al., 2016; Tahamtan et al., 2017; van Houwelingen et al., 2015; Zhang and Koch, 2015); for example, recommendations by senior colleagues, opinion leaders, prominent healthcare organizations, or scientific societies can foster adoption (El Amrani et al., 2017; Bailey et al., 2017; de Vries et al., 2017; Hao and Padman, 2018; James et al., 2016; Kifle et al., 2010; Lord et al., 2016; Molfenter et al., 2015; Nerminathan et al., 2017; Zhang, Cocosila and Archer, 2010).

Adoption is also influenced by the internal context and culture of the healthcare organization (Abd Ghani and Jaber, 2015; Alajlani and Clarke, 2013; Ray et al., 2017), for example, adoption would be clearly discouraged in the case restrictive or unclear expectations around the use of smartphones at work (Beauregard, Arnaert and Ponzoni, 2017; Charani et al., 2013; Farrell, 2016; McNally, Frey and Crossan, 2017; Nerminathan et al., 2017; O'Connor and Andrews, 2018; Payne, Weeks and Dunning, 2014; Tahamtan et al., 2017). Also, organizations that are resistant to change may oppose the introduction of new technologies (Bramley, Mangan and Conroy, 2018; Mandirola Brieux et al., 2017; Goedken et al., 2017; Varsi et al., 2015b). Financial aspects are also vital (Ariens et al., 2017; Jefee-Bahloul, Duchen and Barkil-Oteo, 2016; Morrow et al., 2017; Ray et al., 2017); factors such as lack of funding (Alajlani and Clarke, 2013; Chung et al., 2015; Loh, Flicker and Horner, 2009; Muigg et al., 2018; Odeh et al., 2014; Orchard et al., 2016; Quanbeck et al., 2018; Varsi et al., 2015b; Villalba-Mora et al., 2015), and reimbursement issues (El Amrani et al., 2017; Anderson et al., 2017; Armstrong et al., 2011; Avey and Hobbs, 2013; Chiang et al., 2015; Gagnon et al., 2016; Hickson et al., 2015; Holderried et al., 2018; James et al., 2016; Khan et al., 2015; Kumar, Merchant and Reynolds, 2013; Levine et al., 2014; Lord et al., 2016; Mairesse et al., 2015; Mileski et al., 2017; Moskowitz et al., 2010; Rho, Choi and Lee, 2014; Rogove et al., 2012; van Gaalen et al., 2016) are typical barriers to adoption. A suitable reimbursement scheme and health insurance policy can accelerate adoption (Bishop et al., 2013; Carlisle and Warren, 2013; Choi et al., 2018; Molfenter et al., 2015; Molleda et al., 2017; Ruiz Morilla et al., 2017; Radhakrishnan et al., 2016; Sadoughi et al., 2017; Schneider et al., 2016). Similarly, a tool that reduces costs and helps achieve budget efficiencies is more likely to be adopted (Armstrong et al., 2012; Avey and Hobbs, 2013; Ayatollahi et al., 2018; Mileski et al., 2017; Mueller et al., 2014; Radhakrishnan et al., 2016; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Zilliacus et al., 2010). Yet, ambiguities around cost-effectiveness (Catan et al., 2015; Fairbrother et al., 2014; Lee et al., 2012; Puszka et al., 2016; Seto et al., 2012), and mHealth affordability (Ayatollahi et al., 2018; de Vries et al., 2017; Egerton et al., 2017; Gagnon et al., 2016; James et al., 2016; Jimbo et al., 2013; Jungwirth and Haluza, n.d.; Kayyali et al., 2017; Koval, Kim and Makhlouf, n.d.; Levine et al., 2014; Loh, Flicker and Horner, 2009; Lord et al., 2016; McNally, Frey and Crossan, 2017; Merchant et al., 2015; Molfenter et al., 2015; Moskowitz et al., 2010; van Gaalen et al., 2016; van Houwelingen et al., 2015) may negatively impact adoption.

Clinical evidence generation through mHealth data may increase clinicians' intention to use these tools (Klack et al., 2013; Kleinpell et al., 2016; L'Esperance and Perry, 2016; Mueller et al., 2014; Shaw et al., 2013; Varsi et al., 2015a; Wilhelmsen et al., 2014); but the

perceived lack of evidence is a barrier (Flynn et al., 2009; Levine et al., 2014; Li and Cotton, 2018; Mileski et al., 2017; Moloczij et al., 2015; Muigg et al., 2018; Odnoletkova et al., 2016; Puszka et al., 2016; van Gaalen et al., 2016; Zhang and Koch, 2015), which emphasises the need for more research about the clinical efficacy of mHealth to help promote adoption (Jeon et al., 2014; Kayyali et al., 2017; Kumar, Merchant and Reynolds, 2013). Moreover, clinicians' lack of awareness of these tools may also be a challenge (Alajlani and Clarke, 2013; Miller et al., 2017; Puszka et al., 2016; Zhang and Koch, 2015); therefore, an active promotion of mHealth objectives (Duhm et al., 2016; Gagnon et al., 2016; Kayyali et al., 2017; Khan et al., 2015; Loh, Flicker and Horner, 2009), as well as its benefits and impact on quality of care may increase adoption (Avey and Hobbs, 2013; Cox et al., 2011; de Vries et al., 2017; Dünnebeil et al., 2012; Flynn et al., 2009; Lord et al., 2016; Radhakrishnan et al., 2016; Ray et al., 2017; Sadoughi et al., 2017; Wilhelmsen et al., 2014).

Another vital facilitator is user engagement, as clinicians are more likely to adopt mHealth tools when they were engaged in their development, planning and implementation (Davis et al., 2014; Molleda et al., 2017; Schmeer et al., 2016; Shaw et al., 2013; Varsi et al., 2015b; Walker and Clendon, 2016). Involving practitioners in the development and co-design of these tools (Brewster et al., 2014; Lord et al., 2016), and encouraging user feedback can positively impact adoption (de Vries et al., 2017; Jarvis-Selinger et al., 2011). Unfortunately, some studies reported that clinicians are barely engaged in mHealth development even though it is one of their work tools (Öberg et al., 2017; Radhakrishnan et al., 2016).

2.2.5 Summary: Adoption is about more than a tool's technical features

The systematic literature review allowed the researcher to have a very good overview of what has been previously published about the factors impacting clinicians' adoption of mHealth. Looking at the prevalence of the different categories, it is unexpected and very clear that the social and organizational factors are such a key driver for adoption. This was an important finding to the researcher, because in her practical experience, many people working on mHealth technologies tend to focus more on the technical and material factors when developing and implementing such novel tools, often overlooking some of the crucial social and organizational aspects - perhaps not surprisingly - leading to considerable issues with subsequent widespread adoption.

These key findings should help future researchers to shift their focus from only assessing the tool's features and technical aspects to widen their scope and make sure to incorporate the social factors (such as experiences, skills, culture…), and the organizational factors (like workflow fit, existing workload, roles redefinition…). It should also help the different

stakeholders in defining the needed actions in order to foster adoption. The practical recommendations for policy makers, technology providers, and clinical decision makers are discussed in more detail in the findings and implications section, and visualized in figure 23.

2.3 Review of the most used frameworks in studying mHealth adoption

With Leonardi's methodological guidelines in mind, the researcher wanted to also make sure that she has a good understanding of the different theoretical frameworks used in studying clinicians' mHealth adoption, to ensure a comprehensive analysis of the collected data, to have a better overview of the factors that are pre-defined in the most used frameworks, and any potential gaps that might need to be addressed, so that they can be complemented by the work in this research. Therefore, this section is an in-depth sub-analysis of the systematic literature review to reflect more deeply on the most common theoretical frameworks used in studying adoption. The following sub-sections briefly summarize the high-level findings of the review of the most used frameworks that was conducted in the context of this PhD thesis and published as:

Jacob C, Sanchez-Vazquez A, Ivory C. **Understanding Clinicians' Adoption of Mobile Health Tools: A Qualitative Review of the Most Used Frameworks**. JMIR Mhealth Uhealth. 2020;8(7):e18072. DOI: 10.2196/18072

2.3.1 Overview of the most used frameworks

While the complete systematic literature review yielded 171 studies, only 50 of those used a theoretical framework in their research design. The most commonly used frameworks were diverse forms of extensions of the Technology Acceptance Model (TAM), the Diffusion of Innovation theory (DOI), and diverse forms of extensions of the Unified Theory of Acceptance and Use of Technology (UTAUT) (Jacob, Sanchez-Vazquez and Ivory, 2020b).

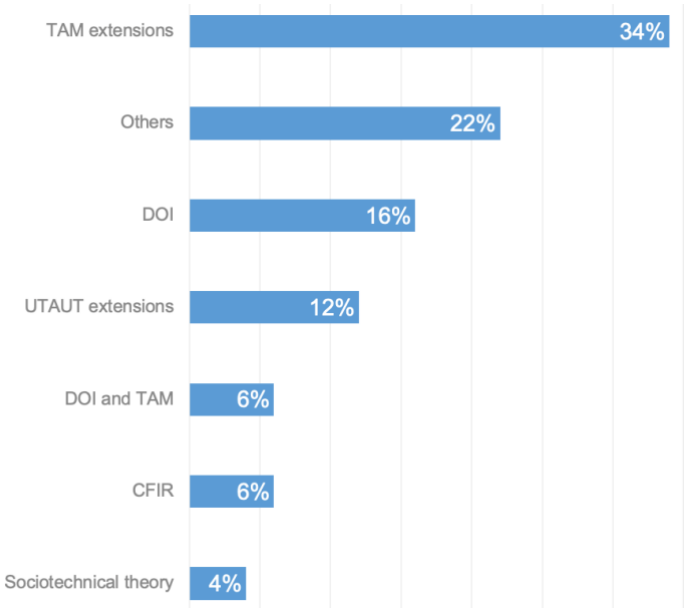
TAM extensions were employed in 34% of the studies (n=17) and sometimes added factors stemming from the literature and the research context (Asua et al., 2012; Jetty et al., 2018; Kowitlawakul, 2011; Orruño et al., 2011; Rho, Choi and Lee, 2014; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Schmeer et al., 2016; Tahamtan et al., 2017; Williamson and Muckle, 2018; Wynn et al., 2012; Zhang, Cocosila and Archer, 2010), or factors from other frameworks such as Chau and Hu's model of telemedicine acceptance and Theory of Interpersonal Behaviour (TIB) (Gagnon et al., 2012b), the Organizational Readiness for Change Model (Ray et al., 2017), Theory of reasoned action (TRA) and Theory of Planned Behaviour (TPB) (Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016), and in combination with the UTAUT (Dünnebeil et al., 2012; Kim et al., 2016).

DOI was used in 16% of the included papers (n=8) (Abd Ghani and Jaber, 2015; Han, Subramanian and Cameron, n.d.; Jarvis-Selinger et al., 2011; L'Esperance and Perry, 2016;

Miller et al., 2017; Puszka et al., 2016; Smith and Buzi, 2014; Zhang and Koch, 2015), and UTAUT extensions in 12%; some of these UTAUT extensions were founded on other published literature or the specific research context (Adenuga, Iahad and Miskon, 2017; Ehrler et al., 2013; van Houwelingen et al., 2015), and other included expansions from other theoretical frameworks such as De Lone and McLean Information Success Model (Hackl et al., 2014), Use of Technology (de Vries et al., 2017), and a combination of TAM, TPB and DOI (Sezgin, Özkan-Yildirim and Yildirim, 2017). Moreover, 6% used a combination of the TAM and DOI frameworks (n=3) (Putzer and Park, 2010, 2012; Sandholzer et al., 2015); 6% used the Consolidated Framework for Implementation Research (CFIR) (n=3) (Lord et al., 2016; Possemato et al., 2017; Varsi et al., 2015b), and 4% used the Sociotechnical Theory (n=2) (Ahmad, Norman and O'Campo, 2012; Casey, Shaw and Swinglehurst, 2017).

Other frameworks were used in 22% of the studies(n=11), including the APEASE (Affordability, Practicability, Effectiveness, Acceptability, Side-effects/Safety and equity) framework (Egerton et al., 2017), an extended De Lone and McLean Information System Success Model (Okazaki et al., 2012), Giddens's structuration theory (Sharma, Barnett and Clarke, 2010), Normalisation Process Theory (Bagot et al., 2017), Organizational Theory of Implementation Effectiveness (Shaw et al., 2013), Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework (Quanbeck et al., 2018), Technological Frames (Grünloh, Cajander and Myreteg, 2016), the Design Science Research Methodology (DSRM) (Lapão, da Silva and Gregório, 2017), Theory of Change (Bramley, Mangan and Conroy, 2018) , and Theory of Planned Behaviour (TPB) (Kuo et al., 2015). An overview of these most used frameworks as detailed in this sub-section is visualized in figure 8.

Figure 8: Overview of the most used frameworks



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020b)

2.3.2 Gap analysis of framework-based versus additional factors from technical, social and organizational perspectives

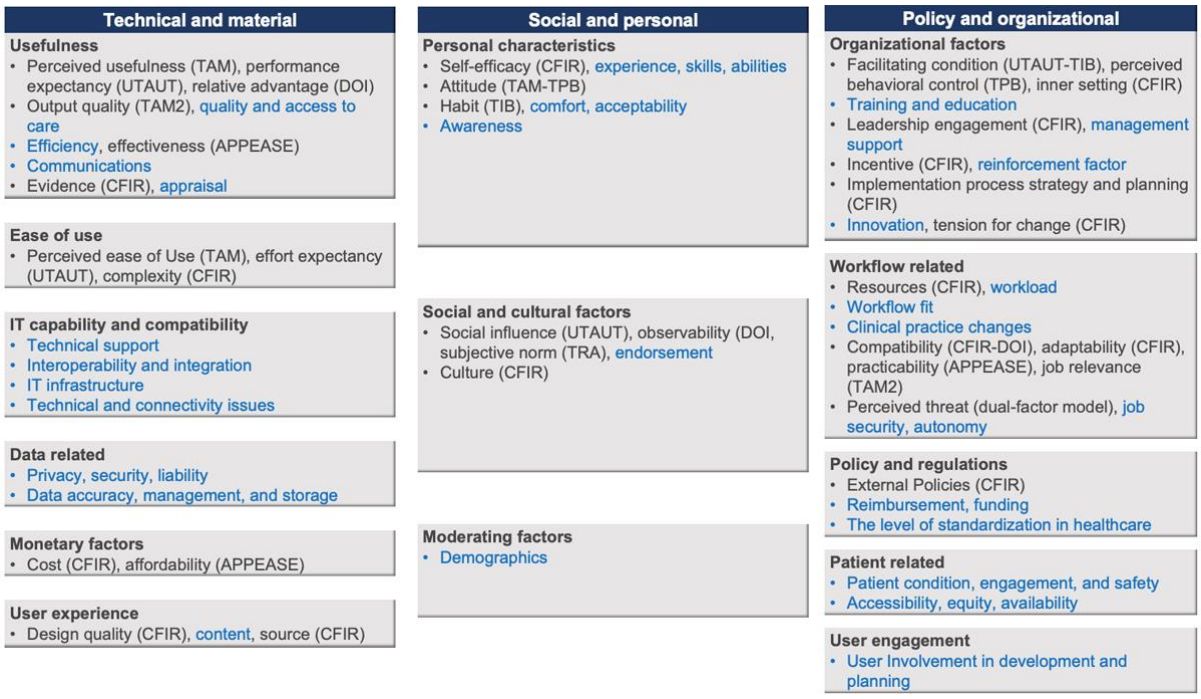
Having defined the theoretical frameworks that are most frequently used in studying clinicians' mHealth adoption, it was important to move on to analyse the framework-based versus additional factors to better recognise potential gaps in the mostly used theories and give suggestions based on the specificities of the healthcare context as reported in the included studies. The detailed analysis of the different factors was published earlier (Jacob, Sanchez-Vazquez and Ivory, 2020b), therefore, this section only summarizes the key overall outcomes of the gap analysis to put them in the context of this thesis.

The factors impacting adoption were categorized according to the theoretical framework into technical, social, and organizations factors. The majority of factors could be connected to one framework or another, however, unexpectedly no single framework could cover all the adoption factors resulting from the analysis unless modified or combined with other models, highlighting the pre-existing gaps in these mostly used frameworks. Figure 9 visualizes the gap analysis of framework-based versus additional factors to make it clear to the reader which constructs could be traced back to one or the other framework, and which ones were not predefined but emerged from the data. In the figure, factors pre-defined in one of the included frameworks comprise the name of the framework following the name of the specific construct between brackets, while the factors that emerged straight from the data but were

not identified as pre-defined constructs in any of the used frameworks are not followed by brackets and are marked in blue font. These added factors typically stemmed from papers that used a qualitative methodology, or were pre-defined by researchers' analysis of earlier studies rather than established frameworks (Jacob, Sanchez-Vazquez and Ivory, 2020b).

Factors with similar meaning were grouped together in the analysis to avoid an overcrowded factors scheme. For instance, when we talk about mHealth usefulness, it can be expressed as perceived usefulness if the research is using TAM, or performance expectancy if the UTAUT is employed, or relative advantage if CFIR or DOI are used. Likewise, the factor ease of use, can be referred to as perceived ease of use if the research is employing TAM, or effort expectancy if using the UTAUT, or complexity if employing CFIR or DOI.

Figure 9: Gap analysis of framework-based versus additional factors



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020b)

Researchers in most of the included papers expanded pre-existing technology acceptance models to be able to examine potentially significant additional factors; however, some academics have criticized such a method of subjectively adding constructs, as it can lead to an inconsistent use of established frameworks (Benbasat and Barki, 2007), highlighting the need for an aggregated framework that covers all these factors in one overview and complements any pre-existing gaps, in order to allow future researchers to have a more consistent approach to the topic, making sure that they do not overlook any of the important adoption factors.

One of the reasons that might have led some of these researchers to add supplementary constructs to pre-existing theories is that some of these frameworks appear oversimplified or not specific enough (Jacob, Sanchez-Vazquez and Ivory, 2020b). For instance, some frameworks stated that usefulness is a key factor, yet, we need to better recognize the aspects that influence the user's perception of usefulness, without this specificity it is hard to take precise actions. For this reason, many of the included research papers operationalized such overgeneralized factors by breaking them down into more precise constructs, for example by asking whether the mHealth app was useful to the job, or if it has improved job efficiency (Jacob, Sanchez-Vazquez and Ivory, 2020b).

2.3.3 Reflection on the frequently used theoretical frameworks

The following sub-sections discuss each of the used frameworks in more detail by giving some background on the frameworks themselves, and some examples of how other researchers used or expanded them. It is followed by another section that discusses a potential consolidated framework that aggregates all these most used frameworks and complements their pre-existing gaps according to the findings of this research.

2.3.3.1 TAM and UTAUT expansions

The TAM was used in 34 % of the included papers; the model was developed by Davis in the late 1980s (Davis, 1989) based on Fishbein and Ajzen's Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1977). The TAM assumes that users' perceived usefulness, and perceived ease of use of technology are the key predictors of their attitude towards using a new tool, which in turn governs the factor called behavioural intention to use that can be interpreted into technology acceptance. Numerous researchers proposed extensions of the initial TAM model to overcome some of its limitations; for example, Holden suggested adding constructs such as individual user aspects, organizational readiness, and trust (Holden and Karsh, 2010); Venkatesh and Davis also expanded the model and called it TAM2, by adding job relevance, subjective norm, voluntariness of use, and image; because these factors were considered to impact perceived usefulness (Venkatesh and Davis, 2000). Venkatesh and Bala stretched the model even more to TAM3 by adding enjoyment and computer anxiety (Venkatesh and Bala, 2008).

The TAM and UTAUT have several resemblances, basically because the latter was based on the former. UTAUT was employed in 12 % of the included studies; it was first published by Venkatesh and Davis (Venkatesh et al., 2003); when they analysed and compared TAM, TAM2, TRA and DOI in an effort to reach a unified technology acceptance model. The

outcome was a new model with four key constructs: 1- performance expectancy, which indicates job usefulness (to match perceived usefulness in TAM); 2- effort expectancy, which indicates the tool's user friendliness and ease of use, (to match perceived ease of use in TAM); 3- social influence, which indicates the degree to which a user's deems that significant others believe they should use the tool and 4- facilitating conditions, which indicates the existence of an organizational and technical infrastructure that can support the tool's use. The revised framework also adds some moderating aspects such as users' age, experience, gender and voluntariness of use. And, behavioural intention to use the new technology is influenced by the three constructs effort expectancy, performance expectancy, and social influence; while the actual tool's usage is then determined by this overall behavioural intention to use together with the construct facilitating conditions.

The majority of the researchers that employed TAM or UTAUT in the included studies, have either added some constructs or expanded the original models to make them more suitable to the specific health care context. This establishes that despite their attractiveness, both frameworks often need some kind of extension to be more appropriated to complex health care contexts. The following lines include the most significant extension examples from the included papers to highlight the constructs that researchers added to these two models.

Two papers added factors from the TIB and TRA to account for the influence of the social context and external factors (Orruño et al., 2011; Gagnon et al., 2012a); they also used Chau and Hu's model (Chau and Hu, 2002) to further segment elements into technical, individual, and organizational factors. They augmented the original framework with factors proposed by TIB, such as compatibility and technical context to account for automatized behaviour, and habit and facilitators to account for the organizational infrastructure. Furthermore, they incorporated the factor subjective norms from the TRA to evaluate if users believe that significant others will support their decision to adopt mHealth. Results from both studies indicated that facilitators were the most important factor in the adapted model, therefore stressing the significance of the organizational context for adoption.

Two other papers extended the TAM with features from the TPB and TRA, with one of them additionally adding factors from the DOI and TR (Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014). The first paper (Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014) included three additional factors: the propensity to innovate (users' inclination to innovate); optimism (the degree to which users consider that mHealth will allow them to gain benefits or reduce effort); and the level of ICT use (the degree to which users use technology in their personal lives). The second

paper (Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016) additionally includes personal technology use (calling it 'ICT user profile') and added other constructs such as data confidentiality and security, costs reduction, and quality improvement. They also considered other factors like the impact of clinicians, patients, and management by assessing their influence on subjective norm. Their results revealed that the most important factors impacting adoption are the resulting cost savings, healthcare data security, and clinicians' technology use in their personal lives.

Another TAM expansion used factors from the DOI and TIB to take into account facilitating conditions, as they were shown in previous research to be among the most significant factors (Asua et al., 2012). Their results established that the facilitators in the organisational setting are the most important factors for mHealth adoption. Similarly, Ray (Ray et al., 2017) extended the model with the Organizational Readiness for change model (Weiner, 2009) by incorporating contextual aspects. Their results confirmed that patient-specific education, detailed clinical protocols, and response times reduction are key factors for adoption.

The Dual-Factor model was also used to extend the TAM, as it incorporates constructs that might hinder adoption, unlike the TAM that focuses more on positive factors such as the tool's ease of use and usefulness (Liu and Cheng, 2015). The study was guided by Walter and Lopez (Walter and Lopez, 2008) who proposed that the perceived threat to professional autonomy may negatively influence mHealth adoption. Furthermore, they added the aspect of perceived mobility as suggested by Huang (Huang, Lin and Chuang, 2007); and their findings confirmed its significance. Other TAM expansions were based on previous research (Rho, Choi and Lee, 2014) and added factors such: accessibility of medical records, self-efficacy, and incentives.

The UTAUT was also extended with various factors; for example, one paper expanded it with reinforcement factors to incorporate the potential impact of incentives on adoption (Adenuga, Iahad and Miskon, 2017). Their results particularly showed the relevance of financial incentives on mHealth use. Another paper combined UTAUT and TAM, and extended them with some additional factors that can influence mHealth ease of use and usefulness (Dünnebeil et al., 2012). Their additional factors included health data security, the intensity of IT use, eminence of documentation, previous mHealth knowledge and process standardization. Comparably, Sezgin (Sezgin, Özkan-Yildirim and Yildirim, 2017) combined UTAUT and TAM, and extended them with factors from TPB and DOI. They incorporated the constructs personal innovativeness and compatibility, as well technology self-efficacy and anxiety.

2.3.3.2 DOI, CFIR, and Sociotechnical Theory

Rogers' DOI theory advocates for the idea that technology adoption goes beyond a tool's technical aspects to also incorporate the usage context (Rogers, 2003); the theory was used in 16% of the included studies, and used in combination with TAM in another 6%. The DOI specifies five features of a technological tool that will foster its adoption: 1- relative advantage (if users believe that it is better than the processes that they currently use), 2- compatibility with users' needs and past experiences, 3- complexity (whether it is difficult to use), 4- trialability (whether it can be piloted on a limited basis), and 5- the observability of the results of its usage. These factors complement the TAM well, as they counterbalance its contextual gaps.

Putzer et al combined elements from DOI and TAM (Putzer and Park, 2010, 2012), following Kwon and Zmund's guidance on the DOI adaptation (Kwon and Zmud, 1987). Their extension included the removal of the trialability construct to avoid potential confusion with observability, and the addition of internal and external environmental factors, in addition to some moderating factors such as demographics. Another DOI expansion was employed by Han et al (Han, Subramanian and Cameron, n.d.) that used Berwick's model (Berwick, 2003) to add three groups of factors: 1- the perception of whether the innovation is helpful, 2- the 'types' of users (e.g. innovators, early adopters…), 3- contextual factors (e.g. social setting). Furthermore, Abd Ghani et al (Abd Ghani and Jaber, 2015) expanded the DOI with the technology-organization-environment (TOE) model (Tornatzky and Fleischer, 1990) to also incorporate individual contexts, as well as the social exchange theory (SE) (Emerson, 1976) to include factors related to power and trust, and implications of aspects such as management support.

The Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009; Damschroder and Hagedorn, 2011), was employed in 6% of the included papers. This framework also takes into account implementation factors, and comprises 39 constructs, clustered in 5 main areas: features of the technological tool, users' characteristics, organizational context, the social setting, as well as the implementation process. Because of its extensive nature, the papers that used this framework did not expand it, they chose it because of its multidimensional nature (Possemato et al., 2017), and its exhaustiveness that allows it to capture the complexity of healthcare settings (Varsi et al., 2015b). However, our findings indicate that the model still has some gaps, like the lack of some specific factors like healthcare system interoperability, data related factors, and reimbursement issues.

The Sociotechnical Theory (STS) (Trist and Bamforth, 1951; Morgan, Trist and Murray, 1992) was employed in 4% of the included papers, and it focuses on the fit between the technical and social factors of a workplace. It deals with organizations as systems incorporating interrelated social and technical subsystems, and necessitate the integration and coordination of these subsystems to achieve optimization. The theory was employed by researchers that aimed to examine the factors that come into play when technology is put into practice (Ahmad, Norman and O'Campo, 2012; Casey, Shaw and Swinglehurst, 2017).

2.3.3.3 Less frequently used Frameworks

Some frameworks only appeared in one of the included publications. However, many of them show the importance of social and organizational factors, and go beyond personal or individual aspects to also integrate the organizational context and its implications for implementation issues that can impact adoption. Several frameworks accounted for the interactions that occur between the social, technical or organizational factors, emphasizing the entanglement between those different facets.

The Normalisation Process Theory (NPT) (May and Finch, 2009; May et al., 2009) addresses the success factors that are needed for the implementation of novel healthcare interventions into routine work or 'normalisation', and proposes a nonlinear understanding of technology acceptance and use, in view of the interdependent connections within organizations. It focuses on four factors: 1- coherence (the course that users undertake when trying to comprehend new practices); 2- cognitive participation (the work that users do to maintain a new practice); 3- collective action (the operational work that users do to endorse a new practice) and 4- reflexive monitoring (the appraisal work undertaken to the effect of new practices). And even though this is one of the few healthcare-specific technology adoption frameworks, it was, surprisingly, the main model used by only one study in this systematic literature review. Bagot (Bagot et al., 2017) employed the NPT in their study, and their results showed – in alignment with what NPT theory proposes – that mHealth implementation requires changes in work practice and the development of new skills in order to succeed.

The Technological Frames (TF) model (Orlikowski and Gash, 1994) focuses on the 'assumptions, expectations, and knowledge' individuals use to better understand new technologies in their organizational setting. The framework encompasses three frames: 1- the nature of technology (people's understanding of the new technology and its features); 2- the technology strategy (the motivation behind user adoption and its value to the organization) and 3- technology in use (how the new technology is being used and the

implication of this use). Grünloh (Grünloh, Cajander and Myreteg, 2016) used the TF to better understand how new technologies impact clinicians' work environment; they could identify relevant work-related factors like the significance of work processes, the existing workload, and control (worries that the new tools may lead to patients controlling the practitioners).

Bidmead (Bidmead and Marshall, 2016) wanted to better investigate the role of the users in the adoption and to make sure that all relevant stakeholders are included; therefore, they employed the stakeholder empowered adoption model (StEAM) (Marshall, 2013). It classifies stakeholders in four groups: professional users (clinicians and care teams), patient users, organisational management (leadership), and technology providers. The study findings showed that the key barriers for adoption are risk averseness, data privacy concerns, and issues related to data integration into the hospital information system.

The theory of planned behaviour (TPB) (Ajzen, 1991) includes three main constructs: 1- users' attitude (their feelings about using the new technology); 2- subjective norms (whether the individual should or should not adopt the new tool) and 3- perceived behavioural control (the availability of the skills, and resources necessary for adoption). It was used by Kuo (Kuo et al., 2015) who's findings confirmed that all three factors can influence technology adoption. Whereas, researchers wanting to address matters like trust and security, which are not truly tackled in most other models, used Gidden's structuration theory (Parsons and Giddens, 1980; Giddens, 2012, 1984). Sharma (Sharma, Barnett and Clarke, 2010) employed the theory in combination with Kouroubali's concept that a better comprehension of social aspects can help resolve possible conflict, and allow an efficacious implementation (Kouroubali, 2002). Their outcomes highlighted the significance of gaining the trust of care teams and promoting a sense of security to foster the adoption of new technologies in healthcare organizations.

The theory of change (W.K. Kellogg Foundation, 2004) takes a different approach, and helps researchers investigate the aspects that would help participants be less resistant to change. Bramley (Bramley, Mangan and Conroy, 2018) used it to examines three stakeholder levels: 1- the macro level (how authorities work with technology providers); 2- the meso level (providers working with practitioners); and 3- the micro level (co-creation and spread of care packages). Their results confirmed that factors like workforce buy-in, leadership engagement, organizational culture, data privacy and safety issues are key for adoption. Similarly, Shaw (Shaw et al., 2013) tackled the matter from an organizational change standpoint using the Weiner Organizational Theory of Implementation Effectiveness

(Weiner, Lewis and Linnan, 2009; Weiner, 2009). The model can help identify the factors impacting an organization's readiness for change, which depends on two main concepts: 1- change valence (the organization's perception of advantages, fit, and need for change) and 2- informational assessment (information about the requirements and availability of resources necessary to implement the change). The research showed the relevance of some organizational barriers like the potential additional workload, shortage of resources, and lack of workflow integration.

Some theories focused more on the design process itself. For example, the APEASE (affordability, practicability, effectiveness, acceptability, side-effects/safety and equity) framework (Michie, Atkins and West, 2014), which is typically used to assess the design of new technologies was employed by Egerton (Egerton et al., 2017). They identified some barriers that may result in resistance to the new tools, such as lack of familiarity with the technology, sense of loss of control, or absence of information and support. Other studies, like Lapao (Lapão, da Silva and Gregório, 2017) used the Design Science Research Methodology (DSRM) (Peffers et al., 2007; Hevner et al., 2004) to investigate the relation between theory and practice by designing, executing and assessing a health tool that addressed a particular need. Their results illustrate that the main barriers for the new technology implementation are the lack of clear role definition, skills and time.

Quanbeck (Quanbeck et al., 2018) examined the implementation process itself, and employed the Reach, Effectiveness, Adoption, Implementation, and Maintenance Framework (RE-AIM) (Glasgow, Vogt and Boles, 1999) to accomplish that. Their outcomes showed that the main barriers are system integration, data management, and the involved costs. Similarly, Okazaki (Okazaki et al., 2012) used an extension of the DeLone and McLean Information System Success Model (DeLone and McLean, 1992) to assess the success of new intervention in a particular organizational setting. They used the original factors of user satisfaction, system and service quality, information quality, and net benefits; and added some supplementary constructs such as data security and privacy risks, ubiquitous control (meaning time and place flexibility), and subjective norms from TPB. They concluded that adoption is most impacted by perceived value and net benefits of the new technology.

2.3.4 Consolidated framework to aggregate and complement the most used models

The review of the most used frameworks in studying mHealth adoption showed that the majority of factors can be related to one model or another, but surprisingly no framework covers all aspects without expansion. Though most frameworks encompass relevant factors,

many of them do not break them down into their specific constituents to allow researchers to assess the precise causes behind specific adoption or implementation challenges, which doesn't help them identify appropriate solutions.

These gaps could be due to that fact that healthcare tools are largely more complex than other technologies that address a single precise need, as they are typically used with patients with comorbidities that are normally treated by interdisciplinary healthcare teams - possibly working in several healthcare organizations. The particular features of how the healthcare sector functions (highly regulated, usual budget deficits, interdependence amongst healthcare organisations) require critical expansions to the current frameworks. This confirms the suitability of the sociotechnical approach, that looks beyond technology itself to also take into account other contextual elements such as social factors, individual characteristics, and organizational setting.

Due to these existing gaps in the mostly used technology acceptance models, researchers in most of the included papers expanded the frameworks that they employed in their research, in order to be able to examine potentially significant additional factors; however, some academics have criticized such a method of subjectively adding constructs, perhaps not surprisingly, as it can lead to an inconsistent use of established frameworks (Benbasat and Barki, 2007), highlighting the need for an aggregated framework that covers all these factors in one overview, and allows future researchers to have a more consistent approach to the topic, making sure that they do not overlook any of the important adoption factors.

This frameworks' review helped shed light on gaps in the most used frameworks, as well as many specificities of healthcare, helping the researcher identify the important factors that should not be overlooked when studying mHealth adoption. Therefore, the researcher proposes a consolidated model that aggregates all the most used frameworks and complements them with the additional factors that emerged from the gap analysis discussed in section 2.3.2. These recommendations are discussed in more detail in the findings and implications section and visualised in figure 21. This consolidated framework should help future researchers adopt a more consistent approach when studying the topic, and cover all the relevant factors in their studies related to mHealth adoption and implementation.

It is worth noting that other researchers identified the same need for an aggregated and healthcare-specific technology adoption framework, hence similar efforts were done in parallel to this research. For instance, the nonadopting, abandonment, scale-up, spread, and sustainability (NASSS) framework (Greenhalgh et al., 2017) had a similar objective, but most probably it didn't come up in the frameworks review in this research due to its recency, as it

was published in November 2017, and the systematic review conducted for this thesis included studies published between January 2008 and August 2018. The NASSS framework not only addresses adoption factors, but also the non-adoption and abandonment of healthcare technologies. It encompasses 7 key factors: the condition or disease, the tool or technology, the value proposition, the adopter system (including healthcare professional, patients, and caregivers), the healthcare organization, the broader context (institutional and societal), and the interplay between all these factors over time. Even though it is quite extensive, the NASSS framework does not call out some of the prominent healthcare-specific technology adoption factors such as EMR integration and harmonization, or reimbursement policies, without which widespread adoption is virtually impossible. The consolidated framework in this thesis calls out such specific and prevalent factors to ensure that future researchers will consider them when studying technology adoption in healthcare.

Furthermore, given the importance of social and organizational factors as reflected in the data, the researcher also suggests an expansion to Leonardi's methodological guidance, to include a fourth step that accounts for user engagement. It was surprising to the researcher that the initial methodological guidelines would stop at understanding how the interaction between the social and the technical materialize at the workplace, without looking into how to ensure that the identified barriers and affordances are taken into account for the further development of the studied technologies. Therefore, this suggested additional fourth step should focus on the mechanisms to engage users, capture their feedback, prioritize it, and take it into account in the tool's constant development. This is discussed in more detail in the findings and implications section and visualised in figure 22.

3 Methodology

This section provides a description and justification of the paradigm and methods used in the research design, data collection, analysis and interpretation. It starts with a summary of the research question to explain why the qualitative paradigm was chosen. Then the study design is described in detail starting with the multiple-case study rationalization, followed by sample selection, data collection techniques, timeframe and location. It concludes with a detailed account of the data analysis method and an explanation of the different phases of thematic analysis.

3.1 Using qualitative research to investigate mHealth adoption

The choice of paradigm is closely related to the questions that the research is addressing; therefore, it is important to remind the reader of the main research questions that this study focuses on. This research, as mentioned earlier, focuses on understanding the factors impacting Clinicians' adoption of MHealth tools and their implications for social and organizational practices. The topic is investigated through the following sub-questions:

- What are the utilities and limitations of mHealth tools as perceived by clinicians?
- What are the factors that constrain or afford clinicians' adoption of mHealth?
- What are the social and organisational implications of this adoption?

Qualitative techniques have become more common in research concerned with the assessment of health technologies as well as health services; this was reflected in the rising numbers of qualitative research published in medical journals (Mays and Pope, 2000). Catherine Pope and Nick Mays wrote five articles in healthcare and health services research explaining why qualitative methods are more suitable than quantitative methods whenever the research is addressing questions such as 'What is Y, how does it vary in different contexts, and why/how?" as opposed to "How many Xs are there?" (Pope and Mays, 1995).

According to Pope and Mays (1995), one of the reasons behind the growing importance of qualitative methods in healthcare research is its ability to address questions that are more concerned with the organization and culture of healthcare professionals, which makes qualitative research crucial for studying health services and understanding the context around them. It enables us to understand the complexities of today's healthcare by touching on complex social aspects such as Clinicians' attitudes and behaviours in ways that cannot be reached by quantitative methods (Pope and Mays, 1995).

The researcher chose this paradigm because it clearly gives precedence to *'the voices of participants'* and the individual and unique *'reflexivity of the researcher'* (Creswell and Poth, 2018, p.8); and because of the rich insights it offers, which will help understand the experiences and perceptions of healthcare professionals in different ways than quantitative methods (Clarke and Braun, 2013; Braun and Clarke, 2014). The clearest argument for the Qualitative paradigm is that it fundamentally pictures the complexity, and sometimes even the contradiction of the real world, and at the same time allows the researcher to identify and understand patterns of meaning (Clarke and Braun, 2013).

In the case of this research, understanding the factors impacting Clinicians' adoption of mHealth tools requires a complex and detailed understanding of their perceptions, which can only be established by having in-depth and detailed discussions with them. Additionally, investigating the implications of this adoption to social and organizational practices necessitates an understanding of the contexts in which these Clinicians operate because their adoption of these tools cannot be separated from their daily work practices.

Within the qualitative paradigm, it is important to differentiate between five key approaches. As shown in Figure 10, these approaches are narrative research, phenomenological research, grounded theory research, ethnographic research, and case study research (Creswell and Poth, 2018). Each one of the five approaches has a specific focus that addresses a particular problem; understanding the research problem for each approach helps the researcher to define their choice of method according to their respective research questions.

Narrative research as a qualitative method can be defined as the procedure of analysing the stories that individuals - the study participants - tell the researcher (Chase, 2008; Clandinin and Connelly, 2000), it focuses on the individual's specific experience but also on exploring the cultural and social contexts that help shape these experiences (Clandinin, 2016). In contrast, the phenomenological research method focuses more on the shared experiences of a group of individuals that lived a shared phenomenon, it investigates what all participants experienced in common facing this specific phenomenon and describes what and how they lived it (Moustakas, 1994; Creswell and Poth, 2018; van Manen, 1990).

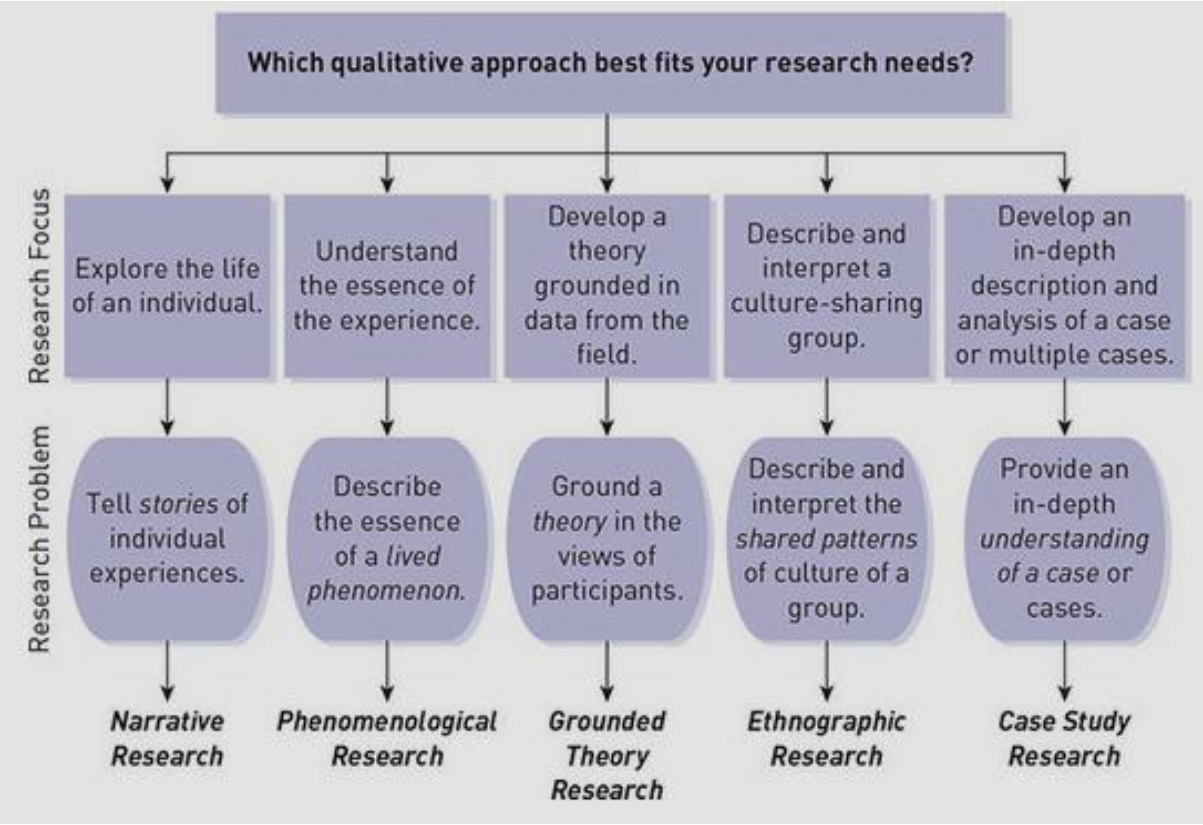
Grounded theory research, unlike narrative and phenomenological research, goes beyond description to create or generate a new theory, a "unified theoretical explanation" addressing a specific action or defined process (Corbin and Strauss, 2007, p.107). This approach aims at explaining what happens in practice and creating relevant frameworks future research by studying how the participants experienced certain processes with distinct

steps that occur over time, enabling the theory to emerge from the data collected from the field (Strauss and Corbin, 1998; Creswell and Poth, 2018); this approach is particularly relevant when there is not an existing theory or framework that can help the researcher understand that studied process (Creswell and Poth, 2018).

While study participants involved in the grounded theory approach are not necessarily located in the same area or frequently interacting together, an ethnographic research on the other hand would rather focus on describing and interpreting the shared patterns of elements such as shared language, culture, belief systems, and individuals' common behaviours (Harris, 1968; Creswell and Poth, 2018), to be able to achieve this, ethnographers engage in extensive fieldwork and typically immerse themselves in the participants' daily lives to gain deeper insights through observation and be able to develop a complex and complete description of the participants' culture and experiences (Creswell and Poth, 2018).

Even though an ethnographic research of a specific culture could be considered a case, the focus of ethnography is on determining how this specific culture functions rather than using it as a case study to investigate a specific problem or question (Creswell and Poth, 2018). In contrast, a single or multiple case study approach would focus on investigating a predefined contemporary issue in a real-life setting of a bounded system (the case, or cases) (Yin, 2017). The case study approach is typically used for "current, real-life cases that are in progress so that they can gather accurate information not lost by time" (Creswell and Poth, 2018, p.97), which makes it a very good fit for a contemporary topic such mHealth adoption, as it is a novel technology that is still unfolding in today's healthcare systems.

Figure 10: Five qualitative approaches to inquiry



Source: (Creswell and Poth, 2018)

The following section explains in more detail why the multiple-case study approach is chosen for this research, and how the researcher addressed the concerns related to this approach to ensure rigor and reliability.

3.2 Multiple-case study as a formal research method

Given the contemporary nature of the topic of mHealth, being a relatively new technology used in healthcare, and the research questions that are focusing not only on the "what" but also on the "how", case study research is deemed appropriate for this study. It has a long history in many disciplines; it is a familiar method to social scientists because of its popularity in areas like psychology, legal cases, case reports in political sciences, as well as case analysis in medicine and healthcare studies (Creswell and Poth, 2018).

Yin (Yin, 2017) explains that there are three main factors that impact the choice of method: The research question itself, and whether it is focused on the "why", the "how" or the "what", the researcher's control over social measures, and the focus on recent versus historical topics and events.

The study's research questions focus on explaining the contemporary topic of mHealth tools usage by clinicians, understanding the "why" behind this usage, and "how" its usage could impact social and organization practices makes the case study method very relevant as it is advantageous when studying contemporary topics that are focused on explaining "why" and "how" certain phenomena happen (Creswell and Poth, 2018; Yin, 2017).

To better understand the uniqueness and richness of the case study method, it is worth looking at this twofold definition:

> *1. "A case study is an empirical method that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident. In other words, you would want to do a case study because you want to understand a real-world case and assume that such an understanding is likely to involve important contextual conditions pertinent to your case.*
>
> *2. A case study copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result benefits from the prior development of theoretical propositions to guide design, data collection, and analysis, and as another result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion."* (Yin, 2017)*.*

This definition shows how choosing the case study method would benefit this research, as it takes the context into account, which is very important for the topic of the usage of mHealth tools by Clinicians because it could potentially impact not only users and how they use technology but also social practices such as roles and hierarchies in healthcare organizations. Therefore, taking the real-world context into account is crucial for an in depth understanding of the topic.

Multiple-case study is a variation of case study research design; it is defined as a case study that includes multiple cases, it allows the researcher to compare the findings of each case, and to identify cross-case patterns to conclude some common patterns and intergroup differences (Bryman and Bell, 2017; Yin, 2017; Creswell and Poth, 2018).

The researcher chose this variation because in most cases, multiple-case studies are likely to be more solid compared to vulnerable single cases where you put all your eggs in one basket; and the different cases are usually cautiously selected in a way that either

anticipates similar results between the cases "*literal replication*" or contrasting results for predictable reasons "*theoretical replication*" (Yin, 2017).

Several of the earlier methodology texts did not consider case studies as a formal research method, but rather as a step in the exploratory phase of another research method(Yin, 2017). However, the method gained considerable acknowledgment in the last few decades, as shown by the growing body of published research and references that successfully applied case study approaches (Creswell and Poth, 2018).

Traditionally, there have been many **concerns raised around case study research** for several reasons such as lack of rigour, non-research case studies that lack a solid methodology, the ability to generalise from a case study, the massive amount of data and documents resulting from them and their comparative advantage when compared to other methods as explained by Yin (2017); however, it is possible to overcome each of them, and the researcher took this into account:

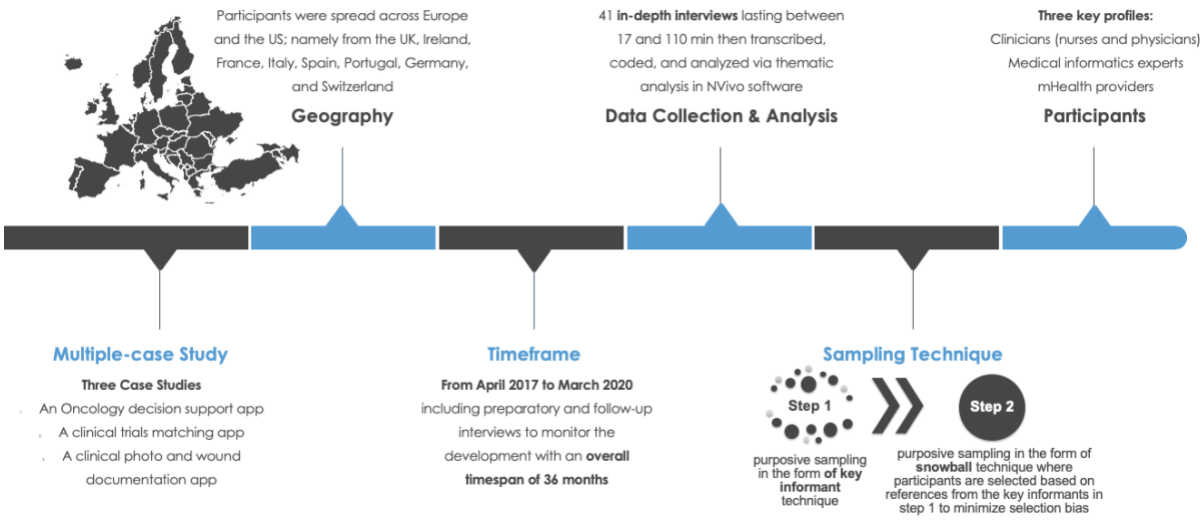
- ***Rigour:*** as explained later in this section, there are ways and procedures that can be taken by the researcher to ensure the highest possible level of rigor and quality.
- ***Non-research case studies***: the researcher will overcome this concern by providing a rich account of the method used to conduct the research, including a clear description of the procedures, with detailed documentation and a fair reporting of the evidence.
- ***Generalizability***: the ability to generalize from a case study has always been a concern, but the same concern can also apply to experimental research, "how would it be possible to generalize from one experiment?" The same generalization approach used with experimental research can also be used here; even though population generalization is not possible in case study research, it is possible to achieve theoretical or analytic generalizations by expanding and generalizing theories.
- ***Required effort***: the researcher designed the study in a way that puts clear boundaries to the timeframe and the kind of data to be collected to make its planning and realization easier.
- ***Comparative advantage***: the researcher argues that case study research can potentially offer insights that cannot be achieved with methods like randomized controlled trials especially when try to investigate the "how "and the "why" certain phenomena happened, like in the case of this research.

3.3 Study design

This section includes the explanation and justification of the study design, starting with the case studies' selection criteria and reasoning, followed by details about the pilot case study selection and handling, then the sample selection method, data collection approach and the timeframe and location.

At a glance, and as shown in figure 11, this is a multiple-case study research focusing on three mHealth tools and their adoption by Clinicians: an oncology decision support app, a clinical trial matching app, and a clinical photo and wound documentation app. Participant profiles varied between clinicians, mHealth developers, and medical informatics experts. The study spanned over a period of 36 months, from April 2017 to March 2020. The researcher conducted 41 in-depth interviews, and analysed them using NVivo qualitative data analysis software. The following sub-sections clarify each of these design elements in detail.

Figure 11: Study design at a glance



3.3.1 Defining the Cases

Defining the cases to be studied is a critical step in the study design and is considered one of the key challenges of this approach, as the researcher recognizes that there are many cases that are potential candidates for the study, and it is important to select the ones that are worth studying (Creswell and Poth, 2018). Selecting cases in multiple-case study designs usually follows a replication logic rather than a sampling one to enable comparison; furthermore, the choice of cases depends on their relevance to the research questions and the possibility to have sufficient access to the data for the selected cases (Yin, 2017).

At the time of case selection for this research, there were more than 325 000 mHealth apps in the app store, however, a deeper look shows that only 45% of these apps get downloaded more than 5000 times, and only 16% have more than 10 000 monthly active users (Research2Guidance, 2017). This information helped the researcher to narrow down the selection to only include apps with a solid user base and an acceptable level of monthly active users to ensure that the selected app is relevant and used often enough for her to recruit an acceptable number of participants.

Bearing in mind that researchers usually pick no more than four or five cases (Creswell and Poth, 2018), the researcher was able to identify three mHealth tools providers, two of them mainly operating in Europe, and one operating in the US with a customer base in Europe as well. She started by researching the available apps in the app store and in peer reviewed journals reporting on relevant apps such as the Journal of Medical Internet Research, then filtered the ones with a clinician interface, and a solid user base. The selected tools were apps that are mainly driven by the clinicians, either because they were primarily created for them, or because they include highly specialized information that cannot be processed and interpreted by the patient alone. These were deemed most suitable for the research question because it focuses on clinician adoption of those apps, making them a decisive element as the gatekeeper to the adoption of these tools.

The operational criteria for case purposeful sampling and selection were:

- An mHealth tool with a clinician interface (excludes tools with patient-only interface)
- The tool has a user base in Europe (even if the tool provider is based elsewhere)
- Willingness to share and collaborate, enabling smooth access

Contacts were identified then contacted first through email or LinkedIn, the professional social platform, to allow for full transparency about the researcher and her background. Almost all the people contacted responded, some declined the request, and a few agreed to discuss further. The novelty of mHealth tools and the competitiveness of this new area in healthcare explain the reason behind many rejections of the researcher's request for collaboration, as it can be challenging to build trust with mHealth providers that have no previous knowledge of the researcher. The case recruitment efforts continued until the researcher successfully recruited three cases, at this point she stopped searching further.

The digital health tools companies that were selected for the study were chosen because, as well as their suitability to the research question, they showed an openness for research engagement and willingness to collaborate and even adapt their application based on the

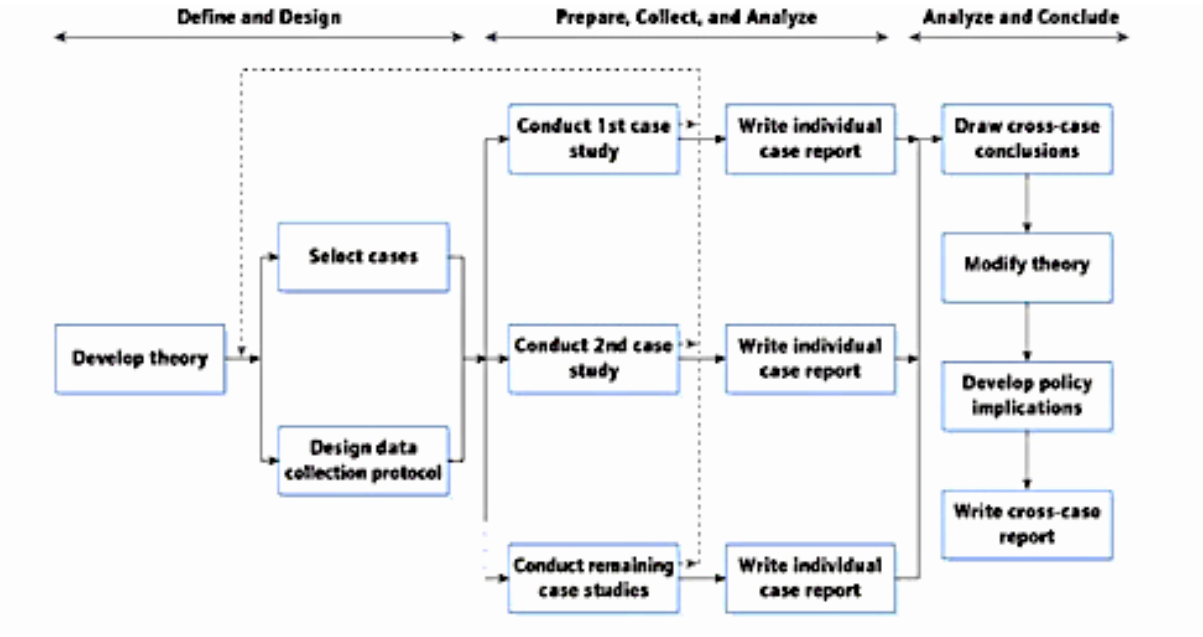
findings of the research. This solves access issues and enables an open in-depth and two-way dialogue between the researcher and the key informants, letting the research shape the existing solution, paving the way to a more solid and refined research themes and protocol. Given the very innovative and competitive nature of the mHealth development sphere a mutual non-disclosure agreement (NDA) was signed with the research partners to facilitate the collaboration and enable access. In two of the three cases the involved parties confirmed an NDA waiver to enable the publishing of the results, the third case remains anonymous and is only included in the aggregated findings in this thesis.

The cases were selected using the replication logic that is suitable for case study research as shown in figure 12. The extensive literature review and theoretical framework are the first and crucial step in identifying the suitable cases and designing the data collection method; subsequently, each case is studied and its results are sought to be replicated in the other cases, concluding with a summary report that highlights the replication logic, and cross-case differences and similarities (Yin, 2017). The feedback loop represented by the dashed-line denotes the case where the research yields an important discovery that necessitates a redesign, a revision of the studied cases or the case study protocol (Yin, 2017).

One way to analyse and report on multiple-case study research is to follow the steps suggested in figure 12, starting by creating an individual report for each case separately conducting a within-case analysis, then have an additional section detailing the cross-case analysis and findings (Yin, 2017; Creswell and Poth, 2018). Alternatively, the researcher could choose not to dedicate separate sections to the individual cases, and rather have a more extensive cross-case analysis section with sub-sections focusing on the different cross-case themes or issues, where the information from the individual cases is spread across these different sub-sections (Yin, 2017).

Given that the researcher has published the individual reports of the two largest cases separately in peer reviewed journals as referenced in the results section, she elected to focus on the cross-case analysis in this consolidated thesis to avoid unnecessary repetition.

Figure 12: Multiple case study procedure



Source: (COSMOS, 1983) as cited in (Yin, 2017)

3.3.2 The case studies

This research included three case studies, starting with a pilot case study that served as a foundational tool that helped the researcher in refining the research protocols, the interview themes, and sometimes offering conceptual clarifications that can be useful for the research design (Yin, 2017). This is aligned with the approach that other researchers adopted, studying a specific case or cases to investigate mHealth experiences, implementation and adoption (Bidmead and Marshall, 2016; Casey, Shaw and Swinglehurst, 2017; Flynn et al., 2009; Lygidakis et al., 2016; Moharra et al., 2015; Molleda et al., 2017; Rothstein et al., 2016; Wilhelmsen et al., 2014).

The digital health tools company that was selected as a pilot was chosen because, as well as their suitability to the research question, they showed an openness for research engagement and willingness to collaborate and even adapt their application based on the findings of the research. This solves access issues and enables an open in-depth and two-way dialogue between the researcher and the key informants, letting the research shape the existing solution, paving the way to more solid and refined research themes and protocol.

Feedback, both verbally and in the form of a written report was shared with the key informants in return for serving as pilot; the researcher's feedback to them, as an external observer, was based on the draft analysis and protocol but adapted and augmented to meet

their needs, and explicitly explaining the lessons learned from the pilot, indicating any adjustments that will be applied in the next cases (Clarke and Braun, 2013; Yin, 2017).

3.3.2.1 Case study 1 (pilot): an oncology decision support app

The first case study, that also served as the pilot study, examined an oncology decision support app created in 2012. It is freely available to oncologists and oncology nurses, with the aim of supporting their decision making at point of care, and it did not comprise a patient interface at the time of the research.

Its key features include adjuvant tools that may be used to get an overall survival of patients with and without chemotherapy in an adjuvant setting, this helps clinicians inform their patients their decision of prescribing chemotherapy or not, this prediction algorithm estimates survival rates for different types of cancer based upon risk factors and treatment. It also includes interactive formulas, also available offline, to allow clinicians to make the essential calculations at point of care (e.g., body surface area / chemotherapy dose calculator to adjust the chemo dosage if a patient's weight changes since the last dosage).

Clinicians may also use the tool to check common toxicity criteria for the standardized classification of adverse effects of cancer therapy drugs, as well as drug information, and a drug interaction checker that allow them to check combinations of drug interactions to identify if they are safe to use. Furthermore, the tool includes prognostic scores that allow clinicians to, for example, predicting survival in patients with a specific type of cancer based on a few questions and patient characteristics. And the AJCC TNM staging feature assists users in their cancer reporting and classification, for example tumour size, affected lymph nodes, and metastases.

3.3.2.2 Case study 2: a clinical trial matching app

The second case study covered a clinical trial matching tool. It is mainly aimed at oncologists and oncology nurses, and it incorporated a patient interface in addition to the clinicians' interface at the time of the research.

Virtual tumour boards and second opinion is one of the tool's key functionalities that aims at bridging the gap between community oncologists and academic oncologists. And their clinical trial matching system uses Artificial Intelligence (AI) to pre-screen the patients to specific clinical trials and aims at helping the patients gain access to trials faster, easing the stress of clinical trial enrolment process and giving the clinicians more time to focus on other patient-related tasks rather than searching the database through hundreds of trials.

Additionally, the tool may be integrated into the hospital or clinic's internal information system and Electronic Medical Record (EMR).

3.3.2.3 Case study 3: a clinical photo and wound documentation app

The third case study assessed a clinical photo and wound documentation app created in 2016. It has a solid user base in Europe, mainly in Switzerland and Germany, and it did not encompass a patient interface at the time of the research.

The app's key features include secure clinical photo and wound documentation, direct patient identification via barcode, precise measurement of the area (but also length, width, circumference) of wounds and specimens, timelines to better understand the patient's progress, classification of images using hashtags to enable photo search, as well as team collaboration via the chat function for second opinions.

3.3.3 The interview guide design

The interview themes and questions were developed in light of Leonardi's methodology and guidance in his paper "Methodological Guidelines for the Study of Materiality and Affordances" in order to crystallize the focus of the data collected in the interviews (Leonardi, 2018).

According to Leonardi's guidance, a solid analysis of the role of technology in organizing and its impact on organizations follows three main steps:

- Understanding and documenting the material aspects of technology and their limitations
- Linking the material aspects of technology to the tasks that they enable and facilitate
- Recognizing the processes resulting from these affordances and determining the consequential interactions taking place in the organization

These three steps are reflected in the research questions, and the following lines give an explanation of how the interview questions stemmed from these three steps by detailing the interview themes and their respective questions. The three steps are kept in the same order defined by Leonardi to respect their cumulative nature, and to allow each step to lead us smoothly into the next one.

The following questions were used in the clinicians' interviews, and were slightly amended for the interviews with the tools' providers and medical informatics experts to suit their

background and role. The complete interview guides for the three participants profiles are included in Appendix 1.

3.3.3.1 Background questions

In addition to the main themes' questions as per Leonardi's guidance, the general background questions below were used at the beginning of the interviews to have a better understanding of the participants' profiles and their experience with mHealth tools.

1. Participant introduction
    - Tell me about your role in the organization
    - How long have you worked in healthcare?
    - How long have you been using mHealth?
    - How would you define your level of technical awareness on a scale of 1 to 10?
2. How would you define mHealth in one sentence?

3.3.3.2 Theme 1: accounting for materials

This theme focuses on understanding the types of technology uses and as well as its limitations. It is crucial to understand the material aspects of mHealth tools because it allows us to identify their utilities as well as things that cannot be done with them due to their material limitations.

Technological features "*can have various degrees of utility based on the forms into which they are cast*" (Leonardi, 2018, p.286), that explains why a good understanding of an app's features, identifying what it can do versus what it cannot do, should help avoid the delusion that users can accomplish limitless tasks with the tools that they use in their daily work. Thus, recognizing not only the utilities but also the limitations of mHealth tools is fundamental for the analysis.

The questions in this section aim at investigating this theme in the context of mHealth tools.

3. Tell me about the mHealth tool that you are using
    - What are its main features?
    - Are there any limitations to its features?
    - If you would add one feature what would it be?
4. How did it help you and your patients?

3.3.3.3 Theme 2: accounting for materiality

This theme evolves around understanding users' perceptions of technology and how they intend to use it, because people's views of technology can influence the way they utilize it in their routine practice (Leonardi, 2018).

Using the lens of sociomateriality, and according to Barley (1981), this is the step where technology is converted from a material object into a social one when people start using it to achieve different tasks, Leornardi (2012) adds that it becomes part of their daily routine and the social and material aspects become imbricated and can hardly be separated any anymore (Leonardi, 2012; Barley, 1981).

Recognizing the constraints and affordances of technology should help the researcher to analyse materiality and the fusion of technology into social practices since "*material properties afford different possibilities for action based on the contexts in which they are used*" (Leonardi, 2018, p.290). This understanding acknowledges that users' intentions and the goals that they want to achieve when using a specific technology has an impact on its affordances.

Hutchby (2001) adds that such affordances go beyond users and technology's properties, and are established based on the kind of relationship formed between people and the technology that they use; accordingly, a tool's affordances can change depending on the context even when its material features remain the same (Hutchby, 2001).

Therefore, questions in this section focus on understanding users' views of mHealth, their usage intentions, decision drivers and what they see as an affordance or a constrain when using it.

5. Tell me about what you wanted to achieve when you decided to use mHealth
6. What were the factors that influenced your decision to adopt mHealth?
    - Which would you consider a barrier and which an opportunity?
7. Who made the decision to implement it? And are there any assessment/selection criteria for such new technologies in your workplace?

3.3.3.4 Theme 3: accounting for materialization

The third and last theme concentrates on how the material aspects of technology change the ways of organizing work and its process. Once the researcher understands a tool's limitations and users' intentions for its use and how this impacts the affordances, it is

important to expand the analysis to understand the impact of technology on the process of organizing (Leonardi, 2018). This focuses on analysing and realizing the cases when particular affordances impact and alter the actions, and relationships that form the organizing process.

The questions in this final section focus on understanding how mHealth impacts the way people interact and organize work and processes in healthcare.

8. What influence did mHealth have on your work/the work of others?
    - Did it improve it?
    - Was the previous practice better for some things?
9. Have these tools led to changes in how the organization works, its rules or the use of other tools / technologies?
10. How have the uses of these tools sustained, altered, or transformed the way that people interact in your organization?
11. In your opinion, what does the future hold for mHealth? And what role could clinicians play in that future?

3.3.4 Sample selection and characteristics

Unlike quantitative research that is dominated by random sampling with the objective of generalizing the results to the wider population, however, the most appropriate technique for this research as in most qualitative research is **purposive sampling** with the objective of rich insights generation (Clarke and Braun, 2013). Therefore, qualitative researchers select potential participants based on their ability to provide rich and in-depth information about the research topic; essentially, they have to be individuals who have personal experience with the topic being studied so they can articulate their real life experiences (Clarke and Braun, 2013; Creswell and Poth, 2018).

Nowadays, the Internet and social media sites offer many opportunities for participant recruitment (Clarke and Braun, 2013). After shortlisting the app cases of interest as per the criteria explained earlier in this thesis, the researcher started contacting **key informants** in these companies via the professional social media site LinkedIn. She chose this platform because it transparently informs the potential participant about her professional experience, background and it also allows them to check others' endorsement of the researcher. It allows the contacted key informant to put a face on the name of the researcher and makes the communication much more personal and relaxed. She almost always received a

response to her enquiry even when the potential participant declined the collaboration request.

After connecting with the key informants in the selected cases of the study, the researcher worked with them to identify suitable participants in their tools' user base. This technique is called **snowballing**, where the researcher builds the sample through the network of other participants, in this case the key informants (Clarke and Braun, 2013). The main selection criteria were that participants must be either healthcare professionals – e.g. physicians, nurses – and are active users of one of the mHealth tools subject of this study, or medical informatics experts supporting the implementation of these tools.

In order to avoid the possible selection bias that might result from the key informants selectively connecting the researcher to users with positive inclination towards the studied solution, the researcher agreed with the key informants that she would ask the users they connected her with if they can in turn connect her to other colleagues that are using the solution and are willing to participate.

As for the satisfactory amount of interviews, there isn't a well-defined cut-off point for data collection in case study method, however, the researcher recognizes an acceptable level of saturation when confirmatory evidence is reached for the key themes, and at the same time this evidence incorporates efforts to examine main rival theories or accounts (Yin, 2017).

A common sample size in research aiming to identify patterns throughout data is somewhere between 15 and 30 interviews; whereas a sample of 50 or more interviews is considered large in qualitative research (Clarke and Braun, 2013). The researcher must be sure to collect enough data to allow her to conduct a rich analysis, but at the same not to collect too much data in a way that makes a deep analysis impossible in the available timeframe; reaching saturation is usually a signal that enough data has been collected, this is when new data does not generate new insights anymore (Braun and Clarke, 2014).

With this in mind, and an overall number of 41 interviews, ranging from 17 to 110 minutes, the researcher is confident that she has reached an acceptable level of saturation. Table 3 shows an overview of the sample characteristics. Most participants were interviewed once, those that were interviewed more than once were members of the providers' teams, and these additional interviews were either introductory interviews to talk in detail about the features and context of the app they provide, or as follow-up interviews to give more detail on how they collect and action user feedback.

The researcher initially intended to conduct a similar number of interviews per case, she succeeded in that with case 1 (n=17) and case 3 (n=20), however, case 2 (n=4) was very challenging as the mHealth provider started some strategic initiatives after starting the research, and due to the confidentiality of the process they were reluctant to refer the researcher to their users at the time, resulting in a limited number of interviews. After discussing with the supervisory team, the researcher decided to still include the 4 interviews from case 2 in the aggregated analysis, despite their small number, because of the rich insights they provide and how they complement the findings from the other two cases.

Table 3: Sample characteristics

	Case 1	Case 2	Case 3	Overall Sample
Number of interviews*	17	4	20	41
Number of participants	13	3	18	34
Function	11 clinicians (one of them is also team member of the tool's provider) 2 more members of the tool's provider team	2 clinicians (both team members of the tool's provider) 1 more member of the tool's provider team	9 clinicians (one of them is also team member of the tool's provider) 5 medical informatics experts 4 more members of the tool's provider team	22 clinicians 5 medical informatics experts 7 mHealth providers
Gender	5 F 8 M	2 F 1 M	3 F 15 M	10 F 24 M
Tech awareness	AVG 7.25	AVG 7.5	AVG 7.5	AVG 7.3
Healthcare experience	AVG years 14.5	AVG years 12.3	AVG years 13.4	AVG years 13.4
mHealth experience	AVG years 7	AVG years 4.5	AVG years 3.9	AVG years 5.1
Participants' Location	United Kingdom, Ireland, France, Italy, Spain, and Portugal	United States	Switzerland and Germany	United Kingdom, Ireland, France, Italy, Spain, Portugal, United States, Switzerland, and Germany

* may include preparatory or follow-up interviews with the same participant ** on a scale of 1 to 10

There was no reward or incentive offered other than the benefit of the study results. This is according to the British Psychological Society's ethical advice against using rewards to avoid

tempting the participants to expose themselves to any harm that they wouldn't otherwise be exposed to (Braun and Clarke, 2014).

3.3.5 Data collection

In accordance to the research paradigm, the researcher decided to use qualitative data collection techniques, emphasizing words rather than numbers while collecting and analysing data; the selected techniques are mainly descriptive with a focus on understanding the world through the eyes of the participants (Bryman and Bell, 2017).

The researcher collected the data mainly through interviews. Case study interview has interchangeably been called an "intensive interview," "in-depth interview," or "unstructured interview" and is more of a guided dialogue than structured enquiries where the researcher follows a general topic and its themes, using a more fluid flow of questions (Braun and Clarke, 2014; Yin, 2017).

Due to the fact that participants were in many different locations, not all interviews were held face to face, most of them were conducted electronically via Skype, Google Hangout, or telephone conferencing, and 4 participants sent their responses electronically via email as they did not have the time for a live call. It is worth noting that digital communication forms are becoming more and more embedded in our daily lives, therefore, the perceptions about them are changing and they are no longer perceived as weaker substitutes to face-to-face interviews, but rather a different format of interview method (Braun and Clarke, 2014).

The researcher made sure to always balance between following the case study protocol and its line of questions with verbalizing the actual interview questions in a conversational and unbiased manner. So, for instance, even though the researcher may want to understand "why" do Clinicians choose to adopt or not adopt an mHealth solution, she was careful with verbalizing the question because "why" questions can easily create defensiveness on the side of the participant; alternatively, verbalizing the question as a "how" question can be perceived as more friendly and nonthreatening, leading to much better results (Yin, 2017).

She developed the interview protocol based on the guidance in Braun and Clarke (2014) and Creswell and Poth (2018) to detail the procedures for preparing and conducting the interview as shown in table 4. Before the interview she designed the interview questions, sent the information sheet to the participant along with the consent form, then scheduled the interview according to the participants' availability; she made sure not to schedule more than one interview per day, allowed enough time for transcription between interviews, and picked

a suitable and comfortable location or tool for the interview (face-to-face, Skype, teleconference, Google Hangout).

During the interview she explained the purpose of the research again, and reminded the interviewees that they can skip any questions they do not wish to answer, she showed interest in what the participant is saying, and made sure not to be judgmental, and made sure to use recording equipment to have a precise record of the interview.

After the interview she made sure to send a thank you note to the participant, to acknowledge their time and effort, transcribed the interview within 2-3 weeks from the date of the interview itself to capture all the details while they are still fresh in her memory, and took note of early reflections.

Table 4: Interview protocol guide: procedures for preparing and conducting interviews

Before the Interview	• Designed the interview questions according to the research questions • Sent the information sheet to the participant • Sent the consent form to the participant • Scheduled the interview according to the participants' availability • Did not schedule more than one interview per day • Allowed enough time for transcription between interviews • Picked a suitable and comfortable location or tool for the interview (face-to-face, Skype, teleconference, Google Hangout)
During the Interview	• Explained the purpose of the research again, and reminded the interviewees that they can skip any questions they do not wish to answer • Showed interest in what the participant is saying, and made sure not to be judgmental • Made sure to use recording equipment to have a precise record of the interview
After the Interview	• Sent a thank you note to the participant, to acknowledge their time and effort • Transcribed the interview within 2-3 weeks from the date of the interview itself to capture all the details while they are still fresh in her memory • Took note of early reflections

Source: Author, after (Braun and Clarke, 2014, pp.90–97; Creswell and Poth, 2018, pp.163–166).

The researcher made sure to follow the protocol, provide a thick description of each step taken in the research and keep a chain of evidence by documenting all procedures in order to allow the readers to follow the derivation of evidence from research questions to findings.

In addition to the interviews, documentary analysis was performed to obtain a solid and clear background about the mHealth tools included, and any related studies and known results or impact (Bryman and Bell, 2017). Public documents and explanatory documents provided on the websites were thoroughly studied as well as the non-public documents provided by the participants and explaining what the apps are designed to do, how they are meant to be used and the consequences expected from their usage.

Furthermore, the researcher collected and analysed physical artefacts such as screenshots of how the app looks like, the devices it can be used on, and example written feedback to the developers (e.g. app reviews on the app store) in order to develop a broader perspective about the tools subject of the study (Yin, 2017).

3.3.6 Timeframe and location

In Creswell's (2018) definition of case studies, he explains that multiple case studies are "*contemporary bounded systems over time*" (Creswell and Poth, 2018, p.96); he explains that the boundaries that the researcher put around the case(s) are crucial in defining the study.

When defining the study's timeframe, the researcher took into account Leonardi and Barley's recommendations about the importance of tracking technology adoption over longer timeframes to have a better understanding of its implications. The studies that they reviewed covered no more than 24 months (Leonardi and Barley, 2010); therefore, the researcher defined a timeframe of 36 months for this study.

The geographical location was initially meant to be focused on Europe, and the second case provider was selected because they have an active user base in Europe; however, due to recruitment difficulties it was only possible to interview the provider's team members that are located in the United States. The researcher still decided to include the data collected from second case because of the rich insights gained from the participants and the fact that two of them are clinicians, and accordingly also presenting the users' perspective not only the providers' side.

Eventually, the research took place in a time period of 36 months, with the research itself starting in April 2017, and the data collection phase continuing from October 2017 until

March 2020. Participants were located in United Kingdom, Ireland, France, Italy, Spain, Portugal, United States, Switzerland, and Germany.

3.4 Data analysis

This section explains the data analysis method choice and the steps taken to analyse the collected data. It starts with an introduction to thematic analysis, explaining what it is and why it was selected for the data analysis. Then, it details the steps taken to do the analysis starting with the audio data preparation for transcription and analysis, followed by familiarization and coding, and concluding with the procedures followed for identifying, analysing and interpreting patterns.

3.4.1 Thematic analysis

After collecting the data, the researcher used thematic analysis to make sense of it by identifying and extracting themes that address the research questions, and explain what each theme could mean as well as the links between themes (Braun and Clarke, 2006).

Thematic Analysis was chosen because of its flexibility and its many advantages such as permitting the process of contrasting data similarities versus differences, generating unforeseen insights and enabling social and psychological data analyses (Braun and Clarke, 2006). It is also extensively adopted in health research since the publication of Braun & Clarke work in 2006 titled “Using thematic analysis in psychology” (Braun and Clarke, 2014).

Furthermore, Thematic Analysis is particularly valuable for researchers working on more applied research aiming at generating results that go beyond academia and benefit the policy or practice domains, which can very well encompass health research. It enables researchers to conduct thorough qualitative analysis that has the potential to get the most out of the data and at the same time present them in a digestible manner to audiences outside the academic body (Braun and Clarke, 2014).

And because thematic analysis is a rather flexible method, the researcher made sure to be explicit and clear about every step in the research and to apply the steps of rigorous research (Braun and Clarke, 2006). To achieve the highest level of accuracy, the researcher decided to follow the systematic method explained by Braun and Clarke (2006), adapted and detailed in table 5. She started by familiarizing herself with the data, transcribing data, reading and re-reading the data, noting down initial ideas. She generated the initial codes by coding interesting features of the data in a systematic fashion across the entire data set,

collating data relevant to each code. Then collated codes into potential themes, gathering all data relevant to each potential theme, and checked if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis. She kept an on-going analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme; then linked the themes to explanatory frameworks, models and concepts. Finally, she proceeded with producing the report.

Table 5: Phases of thematic analysis after Braun & Clarke

Familiarizing yourself with your data	Transcribing data, reading and re-reading the data, noting down initial ideas.
Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
Reviewing themes	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
Defining and naming themes	On-going analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
Linking themes to explanatory frameworks, models and concepts	Making a contribution to theory, reflecting on the validity of different sociomaterial approaches. Building new approaches and theoretical categories and concepts.
Producing the report	The final opportunity for analysis. Selection of a vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Source: After (Braun and Clarke, 2006, p.87).

The following sub-sections explain each of these steps in detail.

3.4.2 Audio data preparation for transcription and analysis

There are different types of transcription explained in the literature; there is orthographic or verbatim transcription where the researcher transcribes everything that was said in the recording, while the other type of transcription includes more paralinguistic descriptions going beyond spoken words to also include the way they were said (Braun and Clarke,

2014). The researcher used orthographic transcription for this study. She also made sure to schedule enough time for transcribing after each interview to minimize any errors resulting from forgetting what was captured in the recorded data, especially if the recording was not very clear for any reason ranging from technical issues to the un-clarity of the participant's voice or pronunciation.

An exception to transcribing everything that was said verbatim is the crucial necessity of anonymizing data for ethical consideration; the researcher made sure to apply this rule, as explained in the transcription notation system recommended by Braun and Clarke (2013), by altering or eliminating any data that could identify the participants, such as their names or the names of other people that they mention.

3.4.3 Familiarization and coding

Unlike quantitative analysis, qualitative analysis is not a linear process, it is a continuous and on-going process of "*Noticing, collecting and thinking about interesting things*"; this progressive process keeps turning in a sequence until saturation, it starts by observing things and noticing them, we then start giving them codes and naming them based on their sense and finally we group them the same way we do with a puzzle, in a way that make them meaningful and emphasizes the differences as well as the patterns (Seidel, 1998).

Therefore, it is not necessary to wait until all data has been collected to start the analysis in qualitative studies; the researcher immersed herself in the data by reading and re-reading transcripts and documents, and started noticing interesting things and casually taking note of them as the research progresses (Braun and Clarke, 2014).

After the data familiarization, the coding – which is a more systematic process – starts. Braun and Clarke (2014) distinguish between two methods of coding: the first is "selective coding" where the researcher identifies a body of interesting instances in a selective manner; and the second is "complete coding" where anything and everything that is relevant to the research questions is identified and given a code. The researcher used the "**complete coding**" method, working systematically through the data, coding data chunks that are relevant to the research questions, and refining codes as the analysis evolved.

In multiple case studies, it is important to structure the coding in a way that helps the researcher to cluster the data by themes within each case, and also by themes that demonstrate similarities and differences in the cross-case analysis (Creswell and Poth, 2018).

Codes can be a word or a brief phrase that explain why a piece of data is relevant to the research question, and they form the building blocks of the analysis. The same data extract can be given as many codes as fits the purpose (Creswell and Poth, 2018; Braun and Clarke, 2014). It is also important to differentiate between codes that reflect the data's semantic content, and those that reflect more theoretical or conceptual explanations. According to Braun and Clarke (2014):

- ***Data-driven or semantic codes*** offer a concise summary of the explicit content of the data; they are grounded in the semantic sense of the data reflecting the participants' language and ideas.
- ***Researcher-driven or latent codes*** go beyond data's explicit content; they represent the researcher's theoretical frameworks and concepts to distinguish the implicit assumptions that underpin what is found in the data.

Table 6 shows the codes used for the analysis, and whether they are data-derived or researcher-derived, as well as the theoretical frameworks where the researcher driven themes originated. These codes were used to group the different issues, and compare the different input about the same point from different participants. The first cluster of themes reflects the tools' utilities versus limitations, the second cluster reflects the technical and material adoption factors, the third cluster reflects the social and individual factors, and the fourth cluster reflects the organizational and policy implications.

Table 6: Researcher driven vs. data driven coding scheme

Theme	**Sub-theme**	**Researcher/ Data Driven**	**Theoretical frameworks where the researcher driven themes originated**
Utilities versus Limitations			
Utilities	Accessibility and compact overview	Data driven	__
	Patient safety and quality of care	Researcher driven	Output quality (TAM2)
	Saving time and efficacy	Researcher driven	Effectiveness (APPEASE)
	Security and validation	Data driven	__
Limitations	Data related	Data driven	__

	Design related	Data driven	—
	System related	Data driven	—
	Resources related	Data driven	—
Technical and material factors			
Data Related	Data management and overload	Data driven	—
	Privacy, security, and liability	Data driven	—
Ease of Use		Researcher driven	Perceived ease of Use (TAM)-Effort expectancy (UTAUT)-Complexity (CFIR-DOI)
IT Capability and compatibility	Interoperability and integration	Data driven	—
	Technical and connectivity issues	Data driven	—
Monetary factors		Researcher driven	Cost (CFIR)-Affordability (APPEASE)
Usefulness	Efficacy and time saving	Researcher driven	Effectiveness (APPEASE)
	Evidence base	Researcher driven	Evidence (CFIR)
	Quality of care	Researcher driven	Output quality (TAM2)
	Usefulness	Researcher driven	Perceived usefulness (TAM)-Performance Expectancy (UTAUT)-Relative Advantage (CFIR-DOI)
User experience	Design, and content reliability/neutrality	Researcher driven	Design Quality (CFIR)- Source (CFIR)
Social and individual factors			
Personal characteristics	Attitude	Researcher driven	Attitude (TAM-TPB)
	Awareness	Data driven	—
	Experience and habits	Researcher driven	Self-Efficacy (CFIR)- Habit (TIB)
	Preference for personal devices	Data driven	—
	Culture	Researcher driven	Culture (CFIR)

Social and cultural factors	Endorsement	Researcher driven	Social Influence (UTAUT)-Observability (DOI)-Subjective Norm (TRA)
Organizational and policy implications			
Inner setting	Apps replacing traditional tools	Data driven	—
	Decision maker	Data driven	—
	Innovation and tension for change	Researcher driven	Tension for change (CFIR)
	Reinforcement factors/incentives	Researcher driven	Incentive (CFIR)
	Training and education	Data driven	—
	Trialability/piloting	Researcher driven	Trialability (CFIR)
Workflow related	Clinical practice and infrastructure	Researcher driven	Compatibility (CFIR-DOI)-Adaptability (CFIR)-Practicability (APPEASE)-Job Relevance (TAM2)
	Collaboration and transparency	Data driven	—
	Empowerment	Data driven	—
	Made the work easier	Data driven	—
	Roles and responsibilities	Data driven	—
	Workflow fit and location flexibility	Data driven	—
	Workload and resources	Researcher driven	Resources (CFIR)
Policy and regulations	Regulations	Researcher driven	External Policies (CFIR)
	Reimbursement and funding	Data driven	—
Patient related	Accessibility and availability	Data driven	—
	Patient engagement and safety	Data driven	—

User engagement	Data driven	—

The coding was done using NVivo that allows a clean and organized coding process and make the grouping and pattern identification easier than what it would be if it were done using printed papers.

3.4.4 Identifying, analysing and interpreting patterns

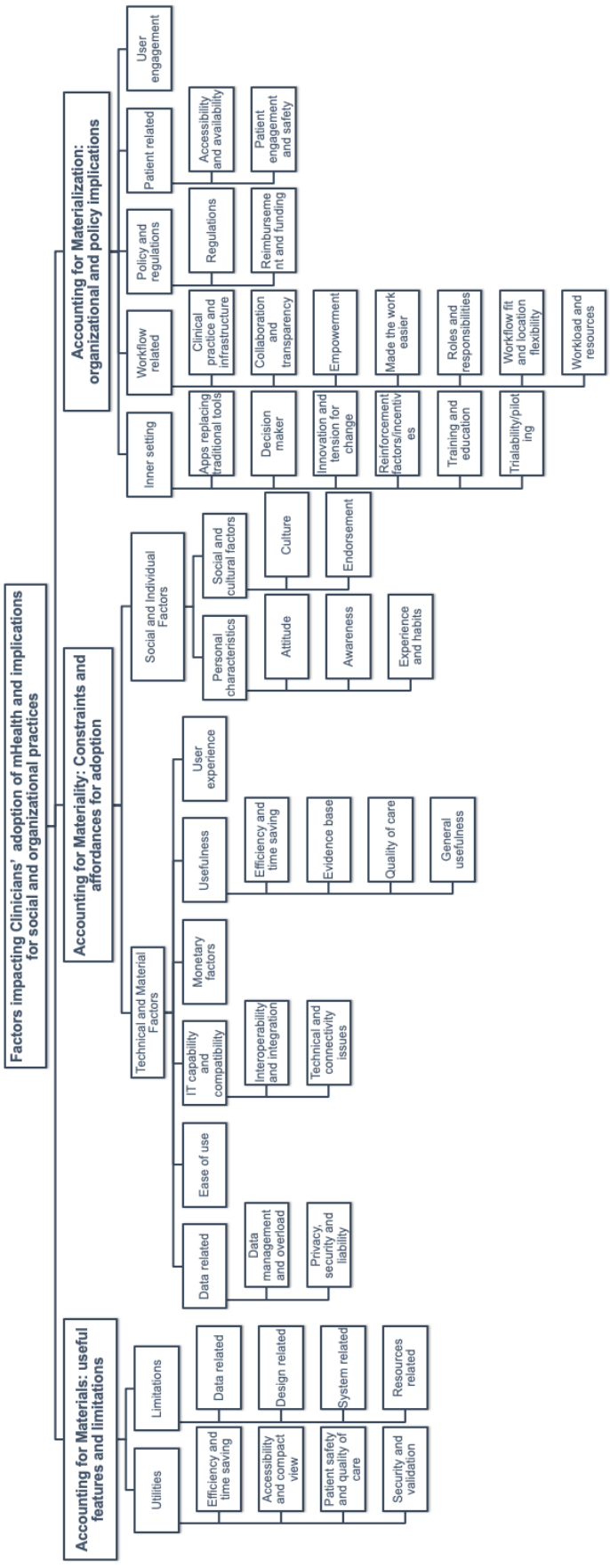
Pattern identification is not a passive process; the researcher develops themes from the coded data by actively examining the codes and the data in order to generate possible patterns. These themes usually cover clustered codes and have “central organizing concepts” capturing data patterns that are relevant to the research questions (Braun and Clarke, 2014; Clarke and Braun, 2013).

As Braun and Clarke (2013) explain, some themes, might not include codes but rather other themes, they are called overarching themes and they help in structuring and organizing the analysis. At the same time, some themes might include sub-themes that capture certain features of the “central organizing concept” of a specific theme. It is important to remember that the most important themes are not necessarily the most frequent, but rather the ones that inform us about something meaningful and significant to address the research question (Braun and Clarke, 2014, 2006).

Figure 13 illustrates a visual thematic map that shows the relationships between overarching themes, themes and sub-themes used in this research. The three main umbrella themes follow Leonardi’s (2018) methodological guidance, by categorizing the data according to his three key steps 1- accounting for the materials: useful features and limitations, 2- accounting for materiality: constraints and affordances for adoption, and 3-accounting for materialization: organizational and policy implications. The umbrella theme (accounting for the materials: useful features and limitations) was split into two themes, on one hand limitations, and on the other hand useful features. The second umbrella theme (accounting for materiality: constraints and affordances for adoption) was also split into two themes, on one hand the technical and material factors, and on the other hand the social and individual factors. Lastly, the third umbrella theme (accounting for materialization: organizational and policy implication) was split into five categories: inner setting of the organization, workflow fit of the mHealth tool, policy and regulations, patient related, and user engagement.

The researcher (CJ) conducted the interviews, and did the analysis and coding, then the second supervisor (ASV) reviewed the coding; any cases of disagreement were discussed in conjunction with the first supervisor (CI), and mutually agreed.

Figure 13: Visual thematic map



The researcher defined each theme to clarify its scope. An overview of these definitions is presented in the table 7, reflecting pre-existing definitions when relevant, e.g., for constructs that were pre-defined in some of the most used frameworks. The first cluster defines the different codes used to express the tools' utilities versus limitations, the second cluster defines the different codes used to express the technical and material adoption factors, the third cluster defines the different codes used to express the social and individual factors, and the fourth cluster defines the different codes used to express the organizational and policy implications.

Table 7: Themes' definitions

Theme	**Sub-theme**	**Definition**
Utilities versus Limitations		
Utilities	Accessibility and compact overview	The perception that the tool has an impact on data accessibility due to the compact overview it gives the users
	Patient safety and quality of care	The perception that the tool has an impact on patients' safety and the quality of patient care. This theme embraces the pre-defined construct 'output quality' (TAM2) which refers to the perceived system's output
	Saving time and efficacy	The perception that the tool helps the user save time and achieve the task at hand more efficiently. This theme embraces the pre-defined construct 'effectiveness' (APPEASE) which refers to the degree to which the tool is successful in producing a desired result; success
	Security and validation	The perception of the level of data security and validation of the tool
Limitations	Data related	Limitations related to data factors
	Design related	Limitations related to the tool's design
	System related	Limitations related to information systems' factors
	Resources related	Limitations related to the available resources
Technical and material factors		
Data Related	Data management and overload	The perception of how easy or complex is the management of the data resulting for the tool's use and whether it may pose an information overload
	Privacy, security, and liability	Medico-legal issues related to health data privacy, security and any liability that this might entail
Ease of Use		This theme embraces the pre-defined constructs 'perceived ease of use' (TAM) which refers to the perceived ease of using the technology, 'effort expectancy' (UTAUT) which

		refers to the perception a user has that the technology is easy to use, and 'complexity' (CFIR-DOI) which refers to the perceived difficulty of the intervention, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement. The degree to which the innovation is perceived as being difficult to understand and use
IT Capability and compatibility	Interoperability and integration	The extent to which the tool is interoperable with the hospital's information system, and whether the tool supports EMR/EHR integration or not
	Technical and connectivity issues	Any technical issues, such as wi-fi and connectivity issues, network issues, login issues…etc
Monetary factors		This theme embraces the pre-defined constructs 'cost' (CFIR) which refers to the costs of the intervention and costs associated with implementing the intervention including investment, supply, and opportunity costs, as well as 'affordability' (APPEASE) which refers to elements such as cost and funding
Usefulness	Efficacy and time saving	The perception that the tool helps the user save time and achieve the task at hand more efficiently. This theme embraces the pre-defined construct 'effectiveness' (APPEASE) which refers to the degree to which the tool is successful in producing a desired result; success
	Evidence base	This theme embraces the pre-defined construct 'evidence' (CFIR) which refers to stakeholders' perceptions of the quality and validity of evidence supporting the belief that the intervention will have desired outcomes
	Quality of care	The perception that the tool enhances the quality of patient care. This theme embraces the pre-defined construct 'output quality' (TAM2) which refers to the perceived system's output
	Usefulness	This theme embraces the pre-defined constructs 'perceived usefulness' (TAM) which refers to the usefulness the individual sees in using the technology, 'performance expectancy' (UTAUT) which refers to the perception a user has that the technology has inherent benefits, and 'relative advantage' (CFIR-DOI) which refers to stakeholders' perception of the advantage of implementing the intervention versus an alternative solution. The degree to which the innovation is perceived as better than the existing process

User experience	Design, and content reliability/neutrality	This theme embraces the pre-defined constructs 'design quality' (CFIR) which refers to perceived excellence in how the intervention is bundled, presented, and assembled; and 'source' (CFIR) which refers to the perception of key stakeholders about who developed the intervention
Social and individual factors		
Personal characteristics	Attitude	This theme embraces the pre-defined construct 'attitude' (TAM-TPB) which refers to the perception of the positive or negative consequences related to adopting the technology; and the positive or negative feelings about using mHealth
	Awareness	The level of users' awareness of the existence of the tool in general, or in their hospital/clinic specifically, as well as their awareness of its features and capabilities
	Experience and habits	This theme embraces the pre-defined constructs 'self-efficacy' (CFIR) which refers to the individual belief in their own capabilities to execute courses of action to achieve implementation goals, and 'habit' (TIB) which refers to users' behavior that has become automatized (out of habit)
	Preference for personal devices	This theme refers to users' preference for using their personal devices at work, which may impact mHealth adoption
Social and cultural factors	Culture	This theme embraces the pre-defined construct 'culture' (CFIR) which refers to norms, values, and basic assumptions of a given organization (or person, or society)
	Endorsement	This theme embraces the pre-defined constructs 'social influence' (UTAUT) which refers to the influence of others on a prospective technology adopter, 'observability' (DOI) which assumes that the easier it is for individuals to see results of the innovation, the more likely they will be to adopt it, and 'subjective norm' (TRA) which refers to the extent to which an individual believes that people who are important to him or her will approve his or her adopting of a particular behavior
Organizational and policy implications		
Inner setting	Apps replacing traditional tools	Users' perception of how new technologies such as mHealth are replacing traditional tools and how this may impact adoption

	Decision maker	The clarity of the decision makers and the decision-making process, when it comes to decisions about the adoption of specific mHealth tools in a healthcare organization
	Innovation and tension for change	This theme embraces the pre-defined construct ‘tension for change’ (CFIR) which refers to the degree to which stakeholders perceive the current situation as intolerable or needing change
	Reinforcement factors/incentives	This theme embraces the pre-defined construct ‘incentive’ (CFIR) which refers to the extrinsic incentives such as goal-sharing awards, performance reviews, promotions, and raises in salary, and less tangible incentives such as increased stature or respect
	Training and education	The availability and quality of the relevant training material and educational programs that help train the users on how to successfully and efficiently use the tool
	Trialability/piloting	This theme embraces the pre-defined construct ‘trialability’ (CFIR) which refers to the ability to test the intervention on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted
Workflow related	Clinical practice and infrastructure	This theme embraces the pre-defined constructs ‘compatibility’ (CFIR-DOI) which refers to the degree of tangible fit between meaning and values attached to the intervention by involved individuals, how those align with individuals’ own norms, values, and perceived risks and needs, and how the intervention fits with existing workflows and systems, ‘adaptability’ (CFIR) which refers to the degree to which an intervention can be adapted, tailored, refined, or reinvented to meet local needs, ‘practicability’ (APPEASE) which refers to the quality of being practicable, viability, and ‘job relevance’ (TAM2) which refers to the importance of the technology for the job
	Collaboration and transparency	The perception that the tool has an impact on team collaboration and transparency
	Empowerment	The perception that the tool enhances the users’ feeling of enablement
	Made the work easier	The perception that the tool facilitated work and made it easier
	Roles and responsibilities	The perception that the tool had an impact on the team members’ roles and responsibilities (e.g. altered some roles, or necessitated the creation of new ones)

	Workflow fit and location flexibility	The perception of the tool's fit into the daily workflow, and how this is impacted by the resulting location flexibility
	Workload and resources	This theme embraces the pre-defined construct 'resources' (CFIR) which refers to the level of resources dedicated for implementation and on-going operations, including money, training, education, physical space, and time
Policy and regulations	Regulations	This theme embraces the pre-defined construct 'external policies' (CFIR) which is a broad concept that includes external strategies to spread interventions, including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting
	Reimbursement and funding	The existence of clear and relevant reimbursement policies that ensures the team's compensation for the tool's use, and the existence of relevant funding for this adoption
Patient related	Accessibility and availability	The perception that the tool enhances access to and availability of care to patients
	Patient engagement and safety	The perception that the tool enhances patients' engagement in their care process, and improves their safety
User engagement		The extent to which the users are involved and engaged in the development, planning and implementation of such new tools

Subsequently, the researcher started to select the excerpts that were used to explain the aspects of each theme, and create an account that tells the narrative of each theme in a way that helps the reader to smoothly understand the analysis. And even though it is not necessary to identify patterns in each data item (Braun and Clarke, 2006), the researcher made sure to balance the data excerpts and drew them unselectively from across the data.

There are two ways to treat such data excerpts in qualitative analysis as explained by Braun and Clarke (2013):

- ***Treating data excerpts illustratively***: where the analytic account offers a comprehensive narrative and explanation of the theme, and the included data excerpts are merely used as illustrations of the analytic arguments that the researcher is claiming.

- ***Treating data excerpts analytically***: where the analytic account offers an analysis of the content of the excerpt itself.

In this research, the researcher treated data excerpts as illustrative examples, which means that the excerpts included in the analysis part do not include all possible data excerpts related to a specific theme but rather examples to help the reader understand the story behind each theme and how it relates to the research questions.

3.5 Ensuring the study's quality

In quantitative research, validity and reliability are used as the criteria for quality assessment; however, in qualitative research, there is a debate about whether the same criteria would be relevant; and even so, those who used validity and reliability as criteria suggested that different definitions should apply for qualitative research (Bryman and Bell, 2017; Braun and Clarke, 2014; Clarke and Braun, 2013).

Consequently, there have been alternative criteria suggested in the literature in order to assess the quality of qualitative research; those are "trustworthiness and authenticity" as explained in Bryman & Bell (2017). Table 8 shows the alternative criteria and how they were taken into account in this research. As shown in the table, credibility in qualitative research, is the equivalent of internal validity in quantitative studies. Its basis is to ensure that the research was done according to 'the canons of good practices' and supports submission of findings to the participants with the aim of confirming that the research has the correct understanding of what the participants intended, the latter is called 'respondent validation' (Bryman and Bell, 2017). Therefore, at different stages of the research, the researcher shared the analysis with the key informants to get their feedback.

Transferability in qualitative research, is the equivalent of external validity in quantitative studies. To allow the judgment of the transferability of the finding to other cases, qualitative researchers are always encouraged to provide 'thick descriptions' that can be explained as 'rich accounts of the details of a culture' (Bryman and Bell, 2017). Therefore, the researcher paid attention to providing a clear description of each step in the research process.

Dependability in qualitative research, is the equivalent of reliability in quantitative studies. It means that the researcher has to ensure the documentation of all phases of the research to obtain a complete record of the whole process (Bryman and Bell, 2017). Therefore, for the sake of this research, a complete record has been kept and is available for review by authorized auditors.

Confirmability in qualitative research, is the equivalent of objectivity in quantitative studies. Even though absolute neutrality is considered impossible in qualitative research, the researcher can demonstrate 'to have acted in good faith'; by showing that her personal values were not allowed to impact the participants or the findings (Bryman and Bell, 2017). Therefore, the researcher made sure not to express personal opinions and ideas during the interviews – unless directly asked – to avoid influencing the participants' answers.

Table 8: Validity and reliability: alternative criteria for qualitative research

Alternative criteria	Equivalent in quantitative	What it means	How it is applied in this research
Credibility	Internal validity	Its basis is to ensure that the research was done according to 'the canons of good practices' and supports submission of findings to the participants with the aim of confirming that the research has the correct understanding of what the participants intended, the latter is called 'respondent validation'. Member validation or respondent validation allows the confirmation of a mutual understanding between the researcher and the participants and accordingly verify the internal validity.	At different stages of the research, the researcher shared the analysis with the key informants to get their feedback.
Transferability	External validity	To allow the judgment of the transferability of the finding to other cases, qualitative researchers are always encouraged to provide 'thick descriptions' that can be explained as 'rich accounts of the details of a culture'.	The researcher paid attention to provide a clear description of each step in the research process.
Dependability	Reliability	It means that the researcher has to ensure the documentation of all phases of the research to obtain a complete record of the whole process including problem	For the sake of this research, a complete record has been kept and is available for review by authorized auditors; to protect the privacy of the participants, only

		formulation, participants' selection, fieldwork notes, interview transcripts, data analysis, and the like; this complete record should allow external audits to evaluate how far the appropriate procedures have been followed.	non-identifiable data would be shared with auditors.
Confirmability	Objectivity	Even though absolute neutrality is considered impossible in qualitative research, the researcher can demonstrate 'to have acted in good faith'; by showing that the researcher's personal values and opinions were not allowed to impact the participants or the findings.	The researcher paid attention not to express personal opinions and ideas during the interviews – unless directly asked – in order to avoid influencing the participants' answers and opinions.

Source: Author, after (Bryman and Bell, 2017)

Furthermore, Yin (2017) identified some tactics that are specifically valid for case study research quality testing as explained in table 9. The table clarifies the definition of each of the four tests, the case study specific tactics to inspect each of them, and how they were applied in this research. As shown in the table, according to the guidance from Yin (2017), to ensure construct validity, key informants in this research were invited to review the draft case study report. To ensure internal validity, the researcher used thematic analysis to match patterns, and build explanations. To ensure external validity, the researcher aimed to reach analytic generalization by using a replication logic with the different cases. And to ensure reliability, she made sure to follow the protocol, provide a thick description of each step taken in the research and keep a chain of evidence by documenting all procedures in order to allow the readers to follow the derivation of evidence from research questions to findings.

Table 9: Tactics to ensure design quality in case-study research after Yin

Test	Definition	Case-study tactics	Application in this research
Construct Validity	Recognizing precise operational procedures for the studied concepts	- Use multiple sources of evidence - Ask the key informants to review the draft case study report	Key informants in this research were invited to review the draft case study report
Internal Validity	(For explanatory or causal studies only and not for descriptive or exploratory studies): seeking to establish a causal relationship, where specific conditions are believed to lead to other associated conditions, as distinguished from spurious relationships	- Do pattern matching - Do explanation building - Address rival explanations - Use logic models	The researcher used thematic analysis to match patterns, and build explanations
External Validity	Showing whether and how a case study's findings can be generalized	- Use theory in single-case studies - Use replication logic in multiple-case studies	The nature of the research question addressing whether HCP adoption to mHealth tools impacts social practices and "how" helps in reaching analytic generalization by using a replication logic with the different cases
Reliability	Establishing that the processes of the study—such as its data collection techniques—can be repeated, and achieving the same results	- Use case study protocol - Develop case study database - Maintain chain of evidence	The researcher made sure to follow the protocol, provide a thick/detailed description of each step taken in the research and keep a chain of evidence by documenting all procedures in order to allow the readers to follow the derivation of evidence from research questions to findings

Source: Author, after (Yin, 2017)

Fundamentally, just like in quantitative research, the best strategy to guarantee rigor in qualitative research, and accordingly its quality, is to use meticulous and precise methods across every step of the research methodology, starting with the research design, the data collection methods, analysis and interpretation, and till communicating the insights (Mays and Pope, 2000).

3.6 Ethical considerations

There are ethical issues that should be considered in any qualitative research; those include the respect for the participants' privacy, to respect their voluntary involvement, to preserve data confidentiality and not to cause any pain on the participants; it is very important to prevent any harm that might be caused to participants; harm can have different forms, such harm to participant's development or self-esteem, stress, or harm to career prospects or chances for future employment (Bryman and Bell, 2017; Creswell and Poth, 2018; Clarke and Braun, 2013).

Table 10 explains in detail the different types of ethical issues that researchers might face in the different phases of their research and how to address each of them as described in Creswell (2018).

Table 10: Ethical issues in qualitative research and how to address them

Phase	Type of Ethical Issue	How to address it
Prior to conducting the study	- Seek university approval - Examine professional association standards - Gain local access permissions - Select a site without a vested interest in the outcome of the study - Negotiate authorship for publication - Seek permission for use of unpublished instruments and procedures that other researchers might consider to be theirs	- Submit for institutional review board approval - Consult types of professional ethical standards - Identify and go through local approvals for the site and participants; find a gatekeeper to help - Select a site that will not raise power issues with researchers - Give credit for the work done on the project; decide on author order - Obtain permission for use of any material that may be considered proprietary and give credit
Beginning to conduct the study	- Disclose the purpose of the study - Refrain from pressure for participants into signing consent forms	- Contact participants and inform them of the general purpose of the study - Assure participants that their participation is voluntary

	- Respect norms and charters of indigenous societies - Have sensitivity to needs of vulnerable populations (e.g. children)	- Find out about cultural, religious, gender, and other differences that need to be respected - Obtain appropriate consent (e.g. parents as well as children)
Collecting data	- Respect the study site and minimize disruptions - Avoid deceiving participants - Respect potential power imbalances and exploitation of participants - Do not "use" participants by gathering data and leaving the site without giving back - Store data of materials (e.g. raw data and protocols) using appropriate security measures	- Build trust and convey the extent of anticipated disruption in gaining access - Discuss the purpose and use of the study data - Avoid leading questions, withhold sharing personal impressions, and avoid disclosing sensitive information - Store data and materials in secure location for 5 years (APA, 2010)
Analysing data	- Avoid siding with participants and disclosing only positive results - Respect the privacy of participants	- Report multiple perspectives, and also report contrary findings - Assign fictitious names or aliases, develop composite profiles
Reporting data	- Avoid falsifying authorship, evidence, data, findings and conclusions - Avoid disclosing information that would harm participants - Communicate in clear, straightforward, appropriate language - Do not plagiarize	- Report honestly - Use composite stories so that individuals cannot be identified - Use language appropriate for audiences of the research - See APA (2010) guidelines for permissions needed to reprint or adapt the work of others
Publishing study	- Share reports with others - Tailor the reporting to diverse audience(s) - Do not duplicate or piecemeal publications - Complete proof of compliance with ethical issues and lack of conflict of interest	- Provide copies of the report to participants and stakeholders - Share practical results, consider website distribution, and consider publishing in different languages - Refrain from using the same material for more than one publication - Disclose funders for research and who will profit from it.

Sources: After (Creswell, 2014; Creswel, 2016; Mertens, Ginsberg and Lincoln, 2014; Mertens and Ginsberg, 2014; Decleene and Fogo, 2012) as cited in (Creswell and Poth, 2018, p.55)

The researcher followed these recommendations thoroughly at each phase of the research to ensure ethical conduct:

- ***Prior to conducting the study***: she went through the necessary ethics trainings, and obtained ethical approval as shown in appendix 2. She identified the relevant key informants, and signed the necessary confidentiality agreements when required.
- ***At the beginning of the study***: the researcher gave an introduction about the research topic both verbally and through the information sheet that was sent to all participants by e-mail prior to interviews, the sheet is included in appendix 3 for reference; the written approval of every participant was asked, and it was always clarified that the participant has the freedom to skip the questions that he or she would not feel comfortable answering or to withdraw from the study altogether, the consent form is included in appendix 4 for reference.
- ***Collecting data***: she built trust with the participants by being transparent and always reminding the participants of their right to drop out of the study or skip the questions that they do not wish to answer, she also avoided any leading or threatening questions. She will make sure to store the transcripts, recorded interviews and all collected data in a secure location for 5 years.
- ***Analysing data***: the researcher made sure to balance all findings and not to focus only on positives; and she kept all interviews recordings and transcripts confidential, only supervisors can have access to them. All quotes used in the research were kept anonymous to protect the privacy of the participants that declared them.
- ***Reporting data***: the researcher reported the findings fairly and avoided the inclusion of any data that would lead to the identification of any of the participants. She also used Turnitin software for plagiarism check to confirm authenticity of the thesis content.
- ***Publishing study***: she shared tailored reports with the key informant at different stages of the research, and published findings in peer reviewed journals. And this research is not funded or sponsored by any party and there is no conflict of interest to declare.

3.7 Role of the researcher

Researchers play a fundamental role in qualitative research, this is because they are considered the instrument of the research, and accordingly the analysis and findings are impacted by their approach and way of evaluating and understanding things (Bryman and Bell, 2017; Clarke and Braun, 2013). The researcher's personality, experience and

background impact the way she makes meaning from data; this doesn't mean that anything would be accepted in qualitative research as some critiques say, but rather that the researcher "*tells one story among many*" that could be told about this specific data (Clarke and Braun, 2013, p.20).

The author of this research holds a M.Sc. in International Management, a B.Sc. in economics, a diploma in business administration, and a postgraduate degree in business research methods; she has over 18 years of professional experience, out of which 10 years in healthcare, mostly in digital strategy roles. She started her consulting firm back in 2016 and works on digital health research, strategy, training and planning with some leading Global healthcare players.

This background empowered her with a strong and wide network in healthcare and enabled her to access key people in the area of Digital Health. This helped her with access to participants, and also fostered a relaxed and mutually beneficial dialogue between her and the key informants. Her passion about digital health and strong belief in its potential motivated her to dig deeper and investigate the topic. She always did her best to stay objective and not to let her personal views impact the analysis or the findings.

4 Results

This section presents the **aggregated and comparative results** of the three cases, given that the individual reports of case 1 and case 3 were published separately in peer reviewed journals, while case 2 was rather narrow because of the limited number of participants, and it remained confidential, its results are only aggregated within the overall results reported in this thesis. The results related to the tools' specific most useful features and limitations can be accessed in the individual reports as follows:

- The individual report for case 1 was published as **Clinicians' Role in the Adoption of an Oncology Decision Support App in Europe and Its Implications for Organizational Practices: Qualitative Case Study**. JMIR Mhealth Uhealth 2019;7(5):e13555. DOI: 10.2196/13555
- The individual report for case 3 was submitted for publishing and is available as **Factors impacting clinicians' adoption of a clinical photo documentation app and its implications for clinical workflows and quality of care - A qualitative case study.** JMIR Mhealth Uhealth 2020;8(9):e20203. DOI: 10.2196/20203

The figures in this section are used in order to visualize the findings, not with the intention of quantifying the data but rather to highlight the occurrence by visually presenting which themes or sub-themes were brought up by more participants than others. The frequency shown in the figures, counts the theme only one time per participant and doesn't accumulate if the same participant brought the same theme up more than once. The visualization primarily aims to improve the understanding of the findings especially when contrasting two factors such as mHealth utilities and limitations (Verdinelli and Scagnoli, 2013), and can provide a clear and simple visual of the central ideas, themes and sub-themes for lay readers (Henderson and Segal, 2013).

4.1 Case study backgrounds and context

This sub-section aims to give the reader more contextual information on the three apps subject of this multiple case study, including more details about their features, their visuals where applicable (when the NDA waiver was signed by the provider) and how long they had been used in practice prior to the study.

The first case study, which also served as the pilot study, examined an oncology decision support app created in 2012, and had been in use for 6 years at the time of the interviews for this study. It is freely available to clinicians, with the aim of supporting their decision making

at point of care, and it did not comprise a patient interface at the time of the research, however, a patient interface was under development at the time.

Its key features include adjuvant tools that may be used to get an overall survival of patients with and without chemotherapy in an adjuvant setting, this helps clinicians inform their patients of their decision to prescribe chemotherapy or not. This prediction algorithm estimates survival rates for different types of cancer based upon risk factors and treatment. It also includes interactive formulas, also available offline, to allow clinicians to make the essential calculations at point of care.

The tool also includes a feature that helps clinicians to check common toxicity criteria for the standardized classification of adverse effects of cancer therapy drugs, as well as drug information, and a drug interaction checker that allow them to check combinations of drug interactions to identify if they are safe to use. Furthermore, the tool includes prognostic scores that allow clinicians to, for example, predict survival in patients with a specific type of cancer based on a few questions and patient characteristics. And the AJCC TNM staging feature assists users in their cancer reporting and classification, for example tumour size, affected lymph nodes, and metastases.

The following list explains the tool's features at the time of writing this thesis in more detail, as per the provider's information and in alignment with the examples shared by the participants (ONCOassist, 2018), and visualized in Figure 14.

- **Adjuvant tools:** can be used to get a 5 and 10-year overall survival of patients with and without chemotherapy in an adjuvant setting, this helps them inform patients as to why they may or may not be prescribing chemotherapy (e.g. Prediction algorithm estimating survival rates for breast/lung/colon/GIST cancer based upon risk factors and treatment).
- **Formulas:** over 20 interactive formulas including offline access to enable clinicians to make the necessary calculations at point of care (e.g. body surface area / chemotherapy dose calculator to adjust the chemo dosage if a patient loses or gains weight since the last prescribed dosage).
- **Prognostic scores:** over 14 prognostic scores enabling clinicians to get the scores they are looking for based on a few questions and patient characteristics (e.g. predicting survival in patients with metastatic renal cell carcinoma).
- **Common Toxicity Criteria:** a set of criteria for the standardized classification of adverse effects of drugs used in cancer therapy.

- **AJCC TNM Staging:** enables an easy and quick feature to help clinicians in their cancer reporting and classification, e.g. Tumor size, Lymph Nodes affected, Metastases.
- **Drug Info:** gives users access to a comprehensive list of oncology specific drugs information allowing them to jump in and out of specific sections quickly.
- **Drug Interaction checker:** enables users to quickly search combinations of drug interactions to identify if they are safe to use.
- **ONCOnews:** allows easy access to most up to date news and information in the field of oncology, personalized based on the user's specialist interests.

Figure 14: First Case Study App Visual

Source: (ONCOassist, 2018)

The second case study covered a clinical trial matching tool. It is an Artificial Intelligence (AI) powered platform mainly aimed at oncologists and oncology nurses, and it incorporated a patient interface in addition to the clinicians' interface at the time of the research. It was launched in 2015, and had been in use for 4 years at the time of the interviews for this study.

Virtual tumour boards and second opinion are among the tool's key functionalities that aim at bridging the gap between community oncologists and their academic counterparts. The clinical trial matching system uses AI to pre-screen the patients to specific clinical trials and aims at helping the patients gain access to trials faster, easing the stress of clinical trial enrolment process and giving the clinicians more time to focus on other patient-related tasks

rather than searching the database through hundreds of trials. Additionally, the tool may be integrated into the hospital or clinic's internal information system and Electronic Medical Record (EMR). It is not visualized here because this case remains confidential as the provider didn't sign an NDA waiver, and therefore visuals and too detailed features cannot be included for confidentiality reasons.

The third case study assessed a clinical photo and wound documentation app that was created in 2016, and had been in use for 3 years at the time of the interviews for this study. It has a solid user base in Europe, mainly in Switzerland and Germany, and it did not encompass a patient interface at the time of the research.

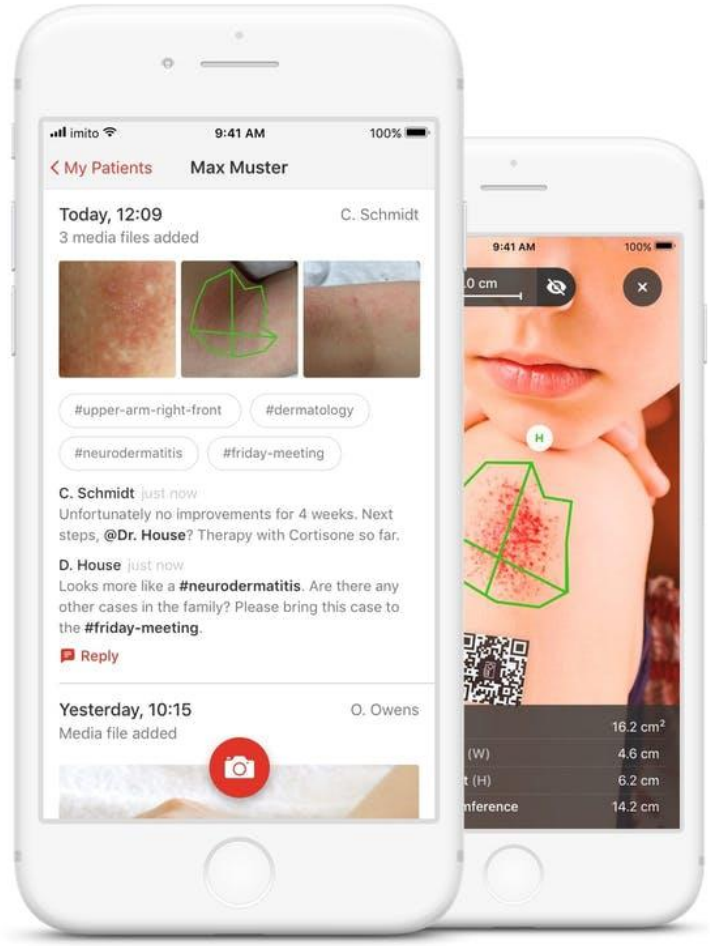
The app's key features include secure clinical photos and wound documentation, direct patient identification via barcode, precise measurement of the area (but also length, width, circumference) of wounds and specimens, timelines to better understand the patient's progress, classification of images using hashtags to enable photo search, as well as team collaboration via the chat function for second opinions.

The following list explains the tool's features at the time of writing this thesis in more detail, as per the provider's information and in alignment with the examples shared by the participants (imito AG, 2019), and visualized in Figure 15.

- **EMR integration**: the app integrates into the hospital's existing application architecture to facilitate the exchange of patient data between the two systems.
- **Simplified login and patient identification**: the app allows users to login via barcode or Radio-frequency identification (RFID) for impersonal devices and, and also enables direct patient identification via barcode
- **Wound measurement**: automatic measurement of the area, length, width and circumference of wounds and specimens
- **Offline and emergency mode:** the app allows clinicians to capture series offline or without patient identification and complete it later on any device.
- **Order-based**: the app uses an order-processing-interface that allows integrated wound photography workflows based on tasks
- **Timeline:** clinicians can use the app to browse through the timeline of one or more findings of a patient to better understand the progression.
- **Interdisciplinary communication**: the app enables team collaboration via chat, e.g. for second opinions.

- **Intelligent search and hashtags**: The categorization of images provides added-value for research and education, enabling users to instantly find other photos with similar characteristics.
- **Melanoma Screening**: clinicians can use the app to document melanomas with the Handyscope (iOS adapter) and save them standardized and automatically calibrated in the patient record. This last feature is provided in cooperation with Fotofinder Systems GmbH.

Figure 15: Third Case Study App Visual



Source: (imito AG, 2019)

4.2 Accounting for the materials: utilities and limitations

At first, the researcher explored each app's mostly used features, their perceived value from the participants' perspective, and any possible limitations or suggested improvements. This information helped in defining each app's utilities and limitations as per figure 16 which

reflects the frequency of each theme (frequencies reflect the number of participants that mentioned that specific theme).

Figure 16: Utilities and limitations

The study participants were first requested to list the features that they use most in the studied app to help the researcher understand the technological artefacts that they find most helpful. These app specific features were published in the individual reports as they are too specific to the individual tools; however, the perceived utilities and limitations are aggregated here in the overall reports given the common patterns that emerged in all three cases.

The researcher asked each participant to explain how the app helped her or him and their patients in their daily work in order to better understand the studied apps' utilities from their

position. Most participants mentioned saving time and efficacy as a clear added value of the apps (n=27, 79%), this utility was reported in the three studied cases; enhanced patient safety and quality of care were also reported by a large portion of the participating clinicians (n=23, 68%), and was reported in the three cases too. Users in the three studied cases also saw value in the better accessibility and compact overview of medical apps (n=14, 41%), and users of the apps in the first and third case studies believed that the apps enhanced data security and validation (n=12, 35%).

In the same way, participants were also asked to talk about any limitations or restraints they might be facing with the studied apps. Data related limitations were the most common and came up in all three cases (n=8, 24%), they varied between issues related to data completeness and accuracy, to information availability and personalisation. Design related constraints emerged in two of the studied cases (n=7, 21%), they were focused on potential information clutter and the lack of some specific features such as a patient interface. System related challenges also emerged in two of the studied cases (n=6, 18%), and mostly evolved around interoperability and connectivity issues. Lastly, resources related issues were mentioned in only one of the three cases (n=2, 6%) and focused on providers' capacity and bandwidth to continuously develop and expand their mHealth tools to meet users' evolving needs. Table 11 summarizes the prevalence of each theme in the aggregated sample, as well as its frequency in each of the three studied cases.

Table 11: Utilities and limitations, theme prevalence per case study

Theme	**Sub-theme**	**Total n(%)**	**Case1 n(%)**	**Case2 n(%)**	**Case3 n(%)**
Utilities	Accessibility and compact overview	**14 (41%)**	7 **(54%)**	1 **(33%)**	6 **(33%)**
	Patient safety and quality of care	**23 (68%)**	8 **(62%)**	1 **(33%)**	14 **(78%)**
	Saving time and efficacy	**27 (79%)**	11 **(85%)**	1 **(33%)**	15 **(83%)**
	Security and validation	**12 (35%)**	3 **(23%)**	__	9 **(50%)**
Limitations	Data related	**8 (24%)**	5 **(38%)**	1 **(33%)**	2 **(11%)**
	Design related	**7 (21%)**	1 **(8%)**	__	6 **(33%)**
	Resources Related	**2 (6%)**	2 **(15%)**	__	__
	System related	**6 (18%)**	2 **(15%)**	__	4 **(22%)**

4.3 Accounting for materiality: constraints and affordances

The second step was about examining each of the studied apps' materiality by investigating the participants' views on the constraints and affordances impacting each tool's adoption from technical and social standpoints. Figure 17 visualizes the themes in the category technical and material factors and their corresponding sub-themes, reflecting the incidence of each of them in the aggregated data.

Figure 17: Technical and material factors

Usefulness was the most dominant theme in the technical and material factors. Most participants stated that the tool's efficacy and the resulting time saving are key facilitators for adoption (n=29, 85%), a factor that was strongly present in all three cases. This efficacy and

time saving were sometimes translated in manpower reduction resulting from the tool's usage as explained by P20 *"So the way we do the analysis of this is we are basically decreasing half day of FTEs per site for patient matching"*, but could also be time saving per individual patient as P30 mentioned *"It created efficiency. Before it (photo documentation) took maybe three, four, five minutes, and now it takes 30 seconds"*.

The tool's capability to enhance the quality of care was another important factor (n=17, 50%), closely followed by general usefulness (n=16, 47%), with the two sub-themes coming up in all three cases; for example, P36 clarifies how the introduction of the app can improve the quality of care *"In the operating room, the photos are not available. So, the clinician has to either just have a good guess what happened in his memory, or get to retrieve the photo somewhere else. (With the app) there is really benefits in the treatments because you have the things available when you need them"*. Participants in the second and third cases also referred to the importance of an evidence base that supports the value of the tool to encourage clinicians' adoption (n=3, 9%); some participants, such as P39 explained that the data generated by such apps can be very helpful for research and evidence generation *"We also expected benefits in terms of scientific studies, simplification of treatment algorithms and networking of inpatient and outpatient treatment pathways"*.

The IT capability and compatibility factors were also central. Participants in all three cases highlighted the importance of the tool's interoperability and integration for it to be accepted by clinicians (n=17, 50%), highlighting that it is usually a challenge as explained by P34 *"The EMR integration in this regard is a challenge both from a cost perspective and the support availability perspective"*; while technical and connectivity issues may also be a barrier to adoption (n=13, 38%) as per participants in two of the three cases. Monetary factors such as the tool's licensing and integration costs were also vital for adoption and present in all three cases (n=17, 50%), as detailed by P39 *"Barriers for establishing such tools are the investment costs, e.g., set up of a secure WLAN, equipment and licensing cost"*. And ease of use was mostly seen as a facilitator in the first and third studied cases (n=19, 56%), participants such P12 explained that if they find an app not easy to use, they would usually abandon it *"I've often downloaded apps and deleted them. But once I download that and see how easy it is, it stayed on my phone" P12*.

Data related factors, especially data privacy, security and liability came up in the second and third cases (n=14, 41%), while challenges related to data management and potential overload were only mentioned by participants in the third case study (n=3, 9%); for example, P26 clarifies *"And the other thing we noticed is that it needs some kind of controlling in the*

future because it is so well accepted that some users overdo it. And we are not limited in terms of data capacity, storage space". User experience factors associated with the tool's design and content reliability and neutrality were mentioned by participants in the first and second cases (n=7, 21%), as P12 explains the importance of factors such as content reliability for user experience *"And so having that, that each time-- as standard, that each time before you're giving your dose that you have, you have this reliable - I suppose that is the word, reliable - calculator for calculating your dose"*. Table 12 summarizes the prevalence of each theme in the aggregated sample, as well as its frequency in each of the three studied cases.

Table 12: Technical and material factors, theme prevalence per case study

Theme	**Sub-theme**	**Total n(%)**	**Case1 n(%)**	**Case2 n(%)**	**Case3 n(%)**
Data Related	Data management and overload	**3 (9%)**	__	__	3 (17%)
	Privacy, security, and liability	**14 (41%)**	__	1 (33%)	13 (72%)
Ease of Use		**19 (56%)**	6 (46%)	__	13 (72%)
IT Capability and compatibility	Interoperability and integration	**17 (50%)**	1 (8%)	3 (100%)	13 (72%)
	Technical and connectivity issues	**13 (38%)**	7 (54%)	__	6 (33%)
Monetary factors		**17 (50%)**	9 (69%)	2 (67%)	6 (33%)
Usefulness	Efficacy and time saving	**29 (85%)**	12 (92%)	3 (100%)	14 (78%)
	Evidence base	**3 (9%)**	__	1 (33%)	2 (11%)
	Quality of care	**17 (50%)**	7 (54%)	2 (67%)	8 (44%)
	General Usefulness	**16 (47%)**	9 (69%)	2 (67%)	5 (28%)
User experience	Design, and content reliability/neutrality	**7 (21%)**	6 (46%)	1 (33%)	__

Table 13 shows some more participants' quotes from the three cases about the technical and material factors impacting mHealth adoption for clarity.

Table 13: Technical and material factors sample participants' quotes

Technical and material factors		
Data Related	Data management and overload	*"And the other thing we noticed is that it needs some kind of controlling in the future because it is so well accepted that some users overdo it. And we are not limited in terms of data capacity, storage space" P26* *"We have more pictures in this time we roll out the devices. So, I do not know if it is always good to have just more content, if it is also in the right context, and is it useful, and that stuff. But we have more" P30*
	Privacy, security, and liability	*"The other major challenge is the data privacy, and all the things that come from the compliance, regulation and transfer" P18* *"the product needs to have a CE mark or a mark as a medical product. Then it needs to be GDPR compliant, of course" P34* *"And altogether you just have to still follow the hospital rules about data security and all that stuff" P33*
Ease of Use		*"I've often downloaded apps and deleted them. But once I download that and see how easy it is, it stayed on my phone" P12* *"It is very important to have an easy self-explanatory tool for nurses to use. Otherwise, they will not do it, understandably" P35*
IT Capability and compatibility	Interoperability and integration	"Our ability to access their EMR system without them needing to physically either send records or have somebody sending the records that they have to pay. Or having to do any additional work on their side. I think that that is a huge thing" P21 *"But there are barriers, mainly the IT integration requirement" P22* *"The EMR integration in this regard is a challenge both from a cost perspective and the support availability perspective" P34*
	Technical and connectivity issues	*"I do not know about your hospital. A lot of hospitals, the way they are, for some reason the signal is never good. And therefore, that also has a bearing on how these apps work" P8* *"of course, an app like this needs a lot of battery. So, we have to load the battery two or three times a day" P32* *"I was too frustrated with the log-in process and now that we have the possibility to log in with face ID, it has proved to be a marvel" P37*
Monetary factors		*"I suppose cost is also a barrier for a few" P15* *"maybe one part of the team, one clinician would like to have it, but they do not have the means to be able to pay for it" P21* *"Barriers for establishing such tools are the investment costs, e.g., set up of a secure WLAN, equipment and licensing cost" P39*
Usefulness	Efficiency and time saving	*"I mean, it is quicker, more efficient than taking out a ruler and a piece of paper and measuring and then go and double checking it" P13* *"So, the way we do the analysis of this is we are basically decreasing half day of FTEs per site for patient matching" P20* *"It created efficiency. Before it (photo documentation) took maybe three, four, five minutes, and now it takes 30 seconds" P30*
	Evidence base	*"the physicians are there because they are more interested in the research and the outcomes" P18* *"We also expected benefits in terms of scientific studies, simplification of treatment algorithms and networking of inpatient and outpatient treatment pathways" P39*

	Quality of care	*"And the intention was to see if this app would help aide my day-to-day clinical decisions and looking after patients" P8* *"It eases the stress of clinical trial enrolment process and gives the HCPs more time to focus on other patient-related tasks" P21* *"In the operating room, the photos are not available. So, the clinician has to either just have a good guess what happened in his memory, or get to retrieve the photo somewhere else. (With the app) there is really benefits in the treatments because you have the things available when you need them" P36*
	General Usefulness	*"Something I can use every day and that is fast" P6* *"The fact that it does actually have things that we do use and which are relevant to us" P8* *"The aspect of creating new possibilities that didn't exist before" P36*
User experience	Design, and content reliability/neutrality	*"And so having that, that each time-- as standard, that each time before you're giving your dose that you have, you have this reliable - I suppose that is the word, reliable - calculator for calculating your dose" P12* *"And we need to keep training it constantly for the machine learning so it actually works in the right way and adapting to the needs of each client or each patient" P20*

As for social and individual factors, they were focused on 6 key sub-themes. Figure 18 visualizes the themes in this category and their corresponding sub-themes, reflecting the incidence of each of them in the aggregated data.

Figure 18: Social and individual factors

Personal characteristics such as users' attitude towards change or technology, previous experiences and habits, awareness, and preferences for personal devices played a clear role in the tools' adoption decision. Participants in the first and third cases clarified that a person's attitude towards change or technology in general may impact their decision to adopt mHealth tools (n=6, 18%), as P7 explains that this can be an individual matter *"But I know people, even people from my age that are somewhat challenged regarding apps in general. So I do not think they would obtain the benefit I do. But of course, this is personal"*. Participants in the second and third cases explained that awareness (n=5, 15%), and previous experiences and habits (n=5, 15%) could also play a role; for example, some users may not choose to adopt a certain tool because they are not aware of how it can help them as P21 clarifies *"they maybe do not understand yet how it (the tool) could benefit them.*

Yeah. Awareness". Some participants also stated that some people's preference for their personal devices may facilitate mHealth adoption (n=3, 9%).

Social and cultural elements should also be taken into account. Participants in two of the three cases elucidated that local and organizational culture (n=4, 12%) can impact adoption, explaining that organization cultures that perceive mobile use at work as waste of time may have a negative impact on the widespread adoption of such apps, as P12 says *"So I think definitely. Unless that you're taking a call, if you're scrolling on your phone, people will automatically presume that you're using it for social media purposes and not for research or education" P12*. Endorsement and recommendations from peers or trusted sources (n=10, 29%) may also influence users' adoption decision; for instance, P9 explains that recommendations from trusted colleagues on social media platforms is what encouraged her to adopt the app *"I went to Young Oncologists Facebook group and everybody was talking about it. And also, one of my colleagues that I really trust a lot for many years now and I decided to install it and download"*. Table 14 summarizes the prevalence of each theme in the aggregated sample, as well as its frequency in each of the three studied cases.

Table 14: Social and individual factors, theme prevalence per case study

Theme	**Sub-theme**	**Total n(%)**	**Case1 n(%)**	**Case2 n(%)**	**Case3 n(%)**
Personal characteristics	Attitude	**6 (18%)**	2 (15%)	__	4 (22%)
	Awareness	**5 (15%)**	__	2 (67%)	3 (17%)
	Experience and habits	**5 (15%)**	__	1 (33%)	4 (22%)
	Preference for personal devices	**3 (9%)**	2 (15%)	__	1 (6%)
Social and cultural factors	Culture	**4 (12%)**	1 (8%)	__	3 (17%)
	Endorsement	**10 (29%)**	9 (69%)	1 (33%)	__

Table 15 shows some more participants' quotes from the three cases about the social and individual factors impacting mHealth adoption for clarity.

Table 15: Social and individual factors sample participants' quotes

Social and individual factors		
Personal characteristics	Attitude	*"But I know people, even people from my age that are somewhat challenged regarding apps in general. So I do not think they would obtain the benefit I do. But of course, this is personal" P7* *"And now with electronic health record opening all of it come these changes that can be challenging for physicians that were not used to that or that are resistant to changes" P29*
	Awareness	*"they maybe do not understand yet how it (the tool) could benefit them. Yeah. Awareness" P21* *"It is more of an awareness and training topic than functionality… to take a picture, that is very easy, you are used from your own cell phone. But if you make a wound measurement, okay, how does it work? And the QR code and-- you have to have some information about this" P30*
	Experience and habits	*"I think that there's a lot of old school doctors who do not want to be bothered by doing this. They think that they can do it on their own and that is fine" P21* *"they (users) could open up finally to this digital transformation because they experienced already one best practice or two or three" P28* *"the medical field, as well, has a new generation now, getting to work more with digital health like a tablet or a Smartphone" P32* *"And then the head of the dialysis found out that she really had people on her staff that didn't have a smartphone. But I think it is not the general population in this ward" P35*
	Preference for personal devices	*"if I have my phone in my pocket. I wouldn't always have access to an iPad or something, if I was on the ward. So that gives me quick access" P12*
Social and cultural factors	Culture	*"So, I think definitely. Unless that you're taking a call, if you're scrolling on your phone, people will automatically presume that you're using it for social media purposes and not for research or education" P12* *"Maybe on this point of view that, if you ever have a phone in your hands, many people think, "Okay. You are gaming something, or you are on social media." But this is a working device. And we are in a change now that the patients-- they see, "Okay. I can do something with the doctor" P30*
	Endorsement	*"So, I would say the encouragement from ESMO is definitely a factor because probably this endorsement in itself has its strength" P8* *"I went for me on to Young Oncologists Facebook group and everybody was talking about it. And also, one of my colleagues that I really trust a lot for many years now and I decided to install it and download" P9* *"…recommendations, they keep following us and recommend other patients. The physicians that have referred to us as well, they still use our tool and sometimes they become advocates for us" P20*

4.4 Accounting for materialization: organizational factors and implications

As a third step, participants were asked about the organizational and policy factors that may impact adoption and their implications for clinical workflow and quality of care, in order to

reflect on how technology use influences the way users organize their work. Figure 19 visualizes the themes in the category organizational and policy factors and implications, and their corresponding sub-themes, reflecting the incidence of each of them in the aggregated data.

Figure 19: Organizational and policy factors and implications

Five key themes dominated the discussions about organizational and policy factors and implications: workflow related factors topped the list, followed by factors relating to the specific inner setting of the organization, then patient related considerations, the importance of user engagement in the development and implementation of mHealth, and external policy and regulatory issues.

Workflow related aspects revolved around seven key sub-themes. Workflow fit and location flexibility, that focus on how the app actually fits in clinicians' daily work, were mentioned by half the participants and strongly present in all three cases (n=17, 50%); P11 gave an example of the location flexibility and enhanced workflow gained from the app use *"for the specific information that I know I have on the apps, I do not have to go to the computer anymore, so I think it is better organized my work because I know that I have that resources there"*, and P30 added *"before, you had to go onto the station, take the camera. Now, you have it in your pocket right next to you. You can log in with the face ID, take a picture and send it"*.

The impact of mHealth use on team collaboration and transparency was also central and mentioned in two of the three cases (n=14, 41%), as P39 explains *"The advantages lie in the improvement of the interdisciplinary cooperation of different medical disciplines and the closer link between inpatient and outpatient treatment pathways"*. The influence on clinicians' ease of work was clear and came up in all three cases (n=11, 32%), P33 gave a good example of how the app can make work easier *"it is easier for the physician to see something in a picture than to read it out of some long description someone did before"*. Participants in two of the three cases also discussed mHealth's impact on clinical practice and infrastructure (n=10, 29%); for instance, P22 explained that some lacking infrastructure in the organization can make the widespread adoption more challenging *"And in some of the hospitals, it is as well the lacking of mobile devices readiness or how to deal with mobile devices, etc. So, it is more an infrastructure or strategic issue there"*.

Factors relating to clinicians' workload and the resources made available to them were mentioned by participants in all three cases (n=8, 24%); some participants such as P21 believed that such apps can have a positive impact on existing workload *"They could also limit the need to have record coordinators. So as we had talked about before, a half or a full FTE. And decrease the time that is lost in sending the records"*, while other participants such as P38 explained that the higher efficiency may also increase the workload because the apps are helping them finish more work more quickly which results in a higher workload overall *"Digitalisation is an aid, but it is currently exacerbating the speed and increasing the challenges to performance. It set a much bigger pressure on working forces by creating more demands and increasing speed of everything"*. Participants in two of the three cases explained that mHealth use may also impact clinicians' empowerment (n=7, 21%) as per the example from P29 *"You have the power of data so it is a gift in who has the knowledge and often it is used by physician. Physician has the knowledge, has the information in his folder and is coordinating everything and it gives him big power"*.

Participants in all three cases explained that the introduction of these new apps may also alter some of the current roles and responsibilities (n=5, 15%), this can be in the form of the creation of new roles as explained by P5 *"having people like myself CCIOs, clinical information officers, to get involved with the IT side of service provision" P5,* but could also be in the form of the elimination of some roles that became obsolete after the introduction of the app as P26 clarified *"our professional patient photographer is consulted less frequently, this has changed… it (the app introduction) altered the role of the photographer, it diminished the role a little bit"*.

The specific inner setting of the organization was also central. The majority of participants mentioned the importance of the decision maker and the internal decision-making process for mHealth adoption, a sub-theme that came up in all three cases (n=20, 59%), the lack of clarity on the decision-making process and the people involved in the decision can be a challenge for adoption as P36 clarified *"I think the problem is nobody's actually willing to make a decision. Everybody wants it. Everybody thinks this is great. But nobody actually says, Yes. This is going to be implemented"*. There were also many discussions in all three cases about how mHealth apps are currently replacing some of the traditional tools in the clinical practice (n=14, 41%); for example, P36 explained how one of the key gains of these novel tools is that they replace processes that used to be done manually *"So, the main aspect, the main benefit, is that the manual process that was previously used, I mean, using a point-and-shoot camera and having to transfer the photos from the camera to the computer and then saving them to the right patient. This whole manual process is, yeah, completely replaced by the automatic process. So, it is a lot of time savings and quality improvements because of the no errors, manual errors, linking the wrong photo to a patient or not linking them at all"*.

The importance of incentives and reinforcement factors to encourage adoption was mentioned by participants in all three cases (n=4, 12%), as P18 expressed *"So there has to be clear incentives, and there has to be very clear resource allocation".* Additionally, the importance of training and education was mentioned in one of the three cases (n=4, 12%), for instance P30 clarified the importance of training the users and informing them about the importance of the new tool in order to encourage adoption *"You have to train the users and show them why it is important"*. Participants in one of the three cases also explained the possibility to try and pilot the app before scaling it could encourage adoption (n=2, 6%), this is mainly due to the reduced risk of a pilot compared to a large-scale implementation, as clarified by P28 *"One of the factors is simply pilot projects are available and recommended to take away the fear that something goes wrong"*.

Patient related factors such as the implications for patient engagement and safety were also pretty vital and were mentioned by participants in all three cases (n=14, 41%); for example, P13 explained that the app usage can enhance patient safety *"It is just a security feature when you need something to fall back on if you're giving a drug and want to ensure you're giving the right dose",* and P36 explained how the app usage can also enhance patient engagement in their own treatment *"Especially in wound care, they often adapt a treatment because a treatment is not necessarily working. And when they have the photos on the smartphone, they can easily talk to the patient and show them that, they can be involved much, much more easily than before because everything is available".* mHealth impact on the accessibility and availability of patient care was mentioned by participants in two of the three cases (n=5, 15%), as it cuts travel times and helps patients access services that they might not have been able to access otherwise, as clarified by P20 *"patients get the state-of-the-art science in front of them so they do not have to travel. They do not have to waste time. Time is golden in cancer",* and P21 *"So it helps to gain more access to clinical trials more quickly".* User engagement was another vital factor that came up in all three cases, stressing the importance of involving the users in the development and implementation of mHealth tools (n=15, 44%).

Many participants also mentioned health policies and regulations as key factors impacting adoption. Reimbursement and funding policies were specifically called out as important factors in two of the three cases (n=5, 15%), for instance, P34 explained how the lack of reimbursement for them of these tools can be challenging for the healthcare organizations *"And there will be no compensation, currently, at least. There will be no compensation for digital solutions, since the federal states are not paying for that... We are working on that. So, we are in close contact with a couple of institutions in the government in order to find some kind of compensation for that kind of expenses"*. Regulations in general were also mentioned as a fundamental factor by participants in one of the three cases (n=3, 9%), for example, regulations related to healthcare data privacy and security may pose a challenge to adoption as P39 clarified *"The limitations and problems are rather in the legal area, as the sending of sensitive patient data is very restrictive.... Legal and technical requirements for secure data transfer must be dealt with"*. Table 16 summarizes the prevalence of each theme in the aggregated sample, as well as its frequency in each of the three studied cases.

Table 16: Organizational and policy factors and implications, theme prevalence per case study

Theme	Sub-theme	Total n(%)	Case1 n(%)	Case2 n(%)	Case3 n(%)
Inner setting	Apps replacing traditional tools	**14 (41%)**	3 (23%)	1 (33%)	10 (56%)
	Decision maker	**20 (59%)**	4 (31%)	2 (67%)	14 (78%)
	Innovation and tension for change	**2 (6%)**	__	__	2 (11%)
	Reinforcement factors/incentives	**4 (12%)**	1 (8%)	2 (67%)	1 (6%)
	Training and education	**4 (12%)**	__	__	4 (22%)
	Trialability/piloting	**2 (6%)**	__	__	2 (11%)
Workflow related	Clinical practice and infrastructure	**10 (29%)**	__	2 (67%)	8 (44%)
	Collaboration and transparency	**14 (41%)**	__	2 (67%)	12 (67%)
	Empowerment	**7 (21%)**	4 (31%)	__	3 (17%)
	Made the work easier	**11 (32%)**	3 (23%)	2 (67%)	6 (33%)
	Roles and responsibilities	**5 (15%)**	3 (23%)	1 (33%)	1 (6%)
	Workflow fit and location flexibility	**17 (50%)**	4 (31%)	1 (33%)	12 (67%)
	Workload and resources	**8 (24%)**	1 (8%)	2 (67%)	5 (28%)
Policy and regulations	Regulations	**3 (9%)**	__	__	3 (17%)
	Reimbursement and funding	**5 (15%)**	__	1 (33%)	4 (22%)
Patient related	Accessibility and availability	**5 (15%)**	__	3 (100%)	2 (11%)
	Patient engagement and safety	**14 (41%)**	1 (8%)	2 (67%)	11 (61%)
User engagement		**15 (44%)**	6 (46%)	1 (33%)	8 (44%)

Table 17 shows some more participants' quotes from the three cases about the organizational and policy factors and implications of mHealth adoption for clarity.

Table 17: Organizational and policy implications sample participants' quotes

Organizational and policy implications		
Inner setting	Apps replacing traditional tools	*"So, the main aspect, the main benefit, is that the manual process that was previously used, I mean, using a point-and-shoot camera and having to transfer the photos from the camera to the computer and then saving them to the right patient. This whole manual process is, yeah, completely replaced by the automatic process. So, it is a lot of time savings and quality improvements because of the no errors, manual errors, linking the wrong photo to a patient or not linking them at all" P36*
	Decision maker	*"I think the problem is nobody's actually willing to make a decision. Everybody wants it. Everybody thinks this is great. But nobody actually says, "Yes. This is going to be implemented" P36*
	Innovation and tension for change	*"And I think competition with other healthcare providers is a topic" P26* *"the fact we use such an app can also be used in communication, that is something that we use as a tool to also kick-off the internal change process in the people and show that (our institution) is an enormous player and open to that kind of innovation" P34*
	Reinforcement factors/incentives	*"So there has to be clear incentives, and there has to be very clear resource allocation" P18* *"think it made changes in a positive way because now we're helping them include structured data in a way that they measure success" P20*
	Training and education	*"And when you have high fluctuation of personnel, then you have the problems. You always have to do the training" P26* *"You have to train the users and show them why it is important" P30*
	Trialability/piloting	*"One of the factors is simply pilot projects are available and recommended to take away the fear that something goes wrong" P28*
Workflow related	Clinical practice and infrastructure	*"And in some of the hospitals, it is as well the lacking of mobile devices readiness or how to deal with mobile devices, etc. So, it is more an infrastructure or strategic issue there" P22*
	Collaboration and transparency	*"It would just facilitate for one larger team I think than having everybody playing one certain role and not being able to budge from that" P21* *"The advantages lie in the improvement of the interdisciplinary cooperation of different medical disciplines and the closer link between inpatient and outpatient treatment pathways" P39*
	Empowerment	*"You have the power of data so it is a gift in who has the knowledge and often it is used by physician. Physician has the knowledge, has the information in his folder and is coordinating everything and it gives him big power" P29*
	Ease of work	*"It is making the work a lot easier for us" P32* *"it is easier for the physician to see something in a picture than to read it out of some long description someone did before" P33*
	Roles and responsibilities	*"having people like myself CCIOs, clinical information officers, to get involved with the IT side of service provision" P5* *"our professional patient photographer is consulted less frequently, this has changed… it (the app introduction) altered the role of the photographer, it diminished the role a little bit" P26*
	Workflow fit and location flexibility	*"for the specific information that I know I have on the apps, I do not have to go to the computer anymore, so I think it is better organized my work because I know that I have that resources there" P11*

		"before, you had to go onto the station, take the camera. Now, you have it in your pocket right next to you. You can log in with the face ID, take a picture and send it" P30 *"it is (the app) embedded within the process and the treatment of patients" P31*
	Workload and resources	*"They could also limit the need to have record coordinators. So as we had talked about before, a half or a full FTE. And decrease the time that is lost in sending the records" P21* *"Digitalisation is an aid, but it is currently exacerbating the speed and increasing the challenges to performance. It set a much bigger pressure on working forces by creating more demands and increasing speed of everything" P38*
Policy and regulations	Regulations	*"The limitations and problems are rather in the legal area, as the sending of sensitive patient data is very restrictive.... Legal and technical requirements for secure data transfer must be dealt with" P39*
	Reimbursement and funding	*"And there will be no compensation, currently, at least. There will be no compensation for digital solutions, since the federal states are not paying for that... We are working on that. So, we are in close contact with a couple of institutions in the government in order to find some kind of compensation for that kind of expenses" P34*
User engagement		*"And then the second is that they realize we're not coming with a solution that we have to onboard the hospital, we do it reverse, we onboard into the hospitals, so they normally stay calm when they realize, aha, you come into our information system, and you work so long until your app works in our system" P28*
Patient related	Accessibility and availability	*"patients get the state-of-the-art science in front of them so they do not have to travel. They do not have to waste time. Time is golden in cancer" P20* *"So, it helps to gain more access to clinical trials more quickly" P21* *"The course of healing can be determined by means of photo documentation and information exchange with e.g., outpatient wound care providers and care facilities. For this, the patient does not necessarily have to be presented in the hospital or specialized facility. Unnecessary and long transport routes for patients e.g., from nursing homes are often preventable" P39*
	Patient engagement and safety	*"It is just a security feature when you need something to fall back on if you're giving a drug and want to ensure you're giving the right dose" P13* *"Especially in wound care, they often adapt a treatment because a treatment is not necessarily working. And when they have the photos on the smartphone, they can easily talk to the patient and show them that, they can be involved much, much more easily than before because everything is available" P36*

4.5 Future vision and the role of clinicians

To close the interviews, participants were asked about their anticipations for the future of mHealth, and the role that clinicians could play in this development. Generally, participants in all three cases agreed that the future of mHealth is quite promising and will have a substantial effect on healthcare. Figure 20 visualizes the themes future vision and the role of clinicians, together with their corresponding sub-themes, reflecting the incidence of each of them in the aggregated data.

Figure 20: Future vision and the role of clinicians

The participants expect an increase in mHealth adoption and acceptance (n=18, 53%), especially with more spread and standardization of EMRs, allowing for better interoperability and integration of such new tools into the hospital's IT system. Clinicians also believe that the efficacies enabled by mHealth use will allow them to adopt a more patient centric approach that better engages patients and empowers them (n=16, 47%). Furthermore, they foresee an immense value in the big healthcare data that such tools generate, and all the possible research using AI to achieve more proactive and predictive treatment model (n=11, 32%). Participants also anticipated better governance and compliance as clinicians become

more familiar with mHealth, and as the healthcare policies and regulations reach a higher level of maturity (n=4, 12%).

Participants also anticipated that clinicians will play a more active role in development and co-creation of mHealth tools in the future (n=9, 27%), and that they will support its spread by being active advocates, taking the lead in mHealth awareness and education (n=7, 21%). Furthermore, they expect the creation of new digital roles for clinicians (n=3, 9%), such as clinical information officers (CCIOs), to get clinicians involved with the technological side of service provision at an early stage and through the whole implementation process.

4.6 Section Summary

The multiple case study results offered rich insights into the factors impacting clinicians' adoption of different mHealth tools. It showcased how social and organizational factors are crucial for the understanding of users' decisions to adopt an mHealth tool or not, and clarified that solely assessing the technical and material factors would not give a complete picture.

The inter-case comparison showed that even though the vast majority of factors were mentioned in all three cases, there were some factors that were more prominent in one case or the other, reflecting the importance of understanding the specificity of each case, and the relative importance of each factor for this specific tool. For example, the factor data management and overload came up only in the third case, because the tool enabled users to create considerably more documents compared to before the tool's introduction, which was not the case with the two other cases. Another example, the factor privacy, security, and liability did not come up in the first case study despite its clear importance in the literature and in the two other cases; this is mainly due to the fact that the tool studied in the first case didn't involve the storage or transmission of any patient data, hence, this factor was not relevant in this specific case, not because it is generally irrelevant but because it doesn't apply for this specific tool.

The findings largely confirmed what the systematic literature review revealed, and the contrast between the study findings and what has been reported in the literature will be discussed in detail in the findings and implications section.

5 Findings and implications

This section discusses the findings of the multiple-case study in contrast with the systematic literature review, and reflects on the theoretical frameworks review in the study context. Consequently, theoretical implications and practical recommendations are explained.

5.1 Multiple case study findings

5.1.1 Understanding mHealth utilities and limitations

Studying technology adoption starts with an understanding of its material features, and a deeper look into its utilities and limitations as perceived by its users (Leonardi, 2018). Participants in the three case studies found the health app that they adopted quite useful, there were similarities in the utilities of the three tools that could be categorized into four main themes: the tool's accessibility and compact overview, enhanced patient safety and quality of care, the potential for saving time and efficacy, data security and validation. The utilities were clearly more prominent in the participants' input compared to limitations; these in turn had similarities in the three cases, with more divergence in the second case. The limited limitations data in the second case could be due to the fact that all interviewees were from the provider's side, and this might have not completely reflected the users' views, even though two of the participants were clinicians. The limitations could also be categorized into four key themes: data related, design related, resources related, and system related limitations.

Most participants found the main utility to be the efficacy and time saving, explaining that the apps made their work quicker and easier, this aligns with previous studies that proposed that expected efficacy gains positively impacts intention to use (Charani et al., 2013; Duhm et al., 2016; Putzer and Park, 2012; Sandholzer et al., 2015; Varsi et al., 2015a; Wilhelmsen et al., 2014; Zhang, Cocosila and Archer, 2010). Better patient care and safety was another prominent utility that prevailed in all three cases as the participants explained how the tools help in treatment optimization, this is in accord with previous research that demonstrated how these tools can facilitate early symptom detection and documentation generating better patient safety (Bishop et al., 2013; Bramley, Mangan and Conroy, 2018; Giraldo et al., 2018; Kleinpell et al., 2016; Li and Cotton, 2018; Moharra et al., 2015; Penny, Bradford and Langbecker, 2018; Seto et al., 2012; Steinschaden, Petersson and Astrand, 2009; Varsi et al., 2015b).

The apps accessibility and their compact overview were perceived as a clear added value in the three cases; such features enable timeliness and facilitate team collaboration, and make them more convenient compared to their potential alternatives, as described in other studies that stressed how the portability of these tools allows the healthcare providers to easily access the relevant information and flexibly complete work tasks regardless of place and time (Nerminathan et al., 2017; Odnoletkova et al., 2016; Puszka et al., 2016; Sadoughi et al., 2017; Sezgin, Özkan-Yildirim and Yildirim, 2017). Participants in two of the three cases were very positive about the data security and validation features of mHealth tools, emphasising the importance of regulatory issues such as GDPR compliance and health data privacy; the absence of this theme in the second case could be due to the fact that all interviewees were from the provider's side, and this might have not completely reflected the users' views and priorities. This is a vital utility given the usual medico-legal issues related to health data anonymity, confidentiality, and potential inappropriate use (El Amrani et al., 2017; Anderson et al., 2017; Ariens et al., 2017; Avey and Hobbs, 2013; Bailey et al., 2017; Brewster et al., 2014; Chang et al., 2017; Davis et al., 2014; de Souza et al., 2017; Hackl et al., 2014; Han, Subramanian and Cameron, n.d.; Hanna, May and Fairhurst, 2012; Hickson et al., 2015; Holderried et al., 2018; Jarvis-Selinger et al., 2011; Jetty et al., 2018; Jimbo et al., 2013; Koval, Kim and Makhlouf, n.d.; Lacasta Tintorer et al., 2018; Mishori et al., 2017; Moskowitz et al., 2010; Muigg et al., 2018; Penny, Bradford and Langbecker, 2018; Quanbeck et al., 2018; Radhakrishnan et al., 2016; Rogove et al., 2012).

As for limitations, the four key categories of factors raised by the participants were similarly reported in former research tackling the topic of clinicians adoption of mHealth, these are typically related to health care data quality and management concerns (Brown et al., 2018; James et al., 2016), possible information overload (Levine et al., 2014; MacNeill et al., 2014; Öberg et al., 2017), in addition to system integration and exchange issues (Bidmead and Marshall, 2016; Catan et al., 2015; Chung et al., 2015; Loh, Flicker and Horner, 2009). This latter barrier related to technological interoperability confirms the idea that frequently it is the software itself rather than the tool's features that can be restrictive to technology use (Leonardi, 2018), in the same way, clinicians sometimes resit tools with very useful features only because they do not integrate well with their hospital's information system.

It was also noteworthy to see that some of the features that participants wished to add to the mHealth tool that they are using were already available. This shows that users were not always informed about all existing functionalities, and highlighting the fundamental role of training. This thought was underlined by Oudshoorn and Pinch when they rationalised that the adoption of new technological tools typically hangs on the users' awareness of their

features and their understanding of what they can accomplish them, expressing that "*It has long been recognized that the most sophisticated and complex computer hardware and software will come to naught if users do not know how to use them*" (Oudshoorn and Pinch, 2003). Some of the additional features requested by the participants, are already under consideration by the respective mHealth providers but are occasionally hindered because of their elevated development costs.

5.1.2 Understanding mHealth's constraints and affordances

Moving on now to consider what a technological tool can afford or constraint, it is important to examine how users essentially perceive and adopt these technologies in their daily life; this is usually where technology becomes entangled with social practices as users make sense of the tools that they use (Leonardi, 2018). Therefore, it was important to better understand how the participants believe that the tools they adopted helped them and their patients, this is of particular importance because as Gibson suggests, users might renounce a specific technical tool if they do not know what it is good for (Gibson, 1986).

The findings showed that adoption decisions, and the related barriers and opportunities, are not solely based on the technical and material factors as the tool's features, but also comprises some vital social and cultural elements. Factors related to users' individual characteristics may impact their technology acceptance; for example, participants explained that people's previous technology experience, and whether they have used mHealth before, may impact their decision, as formerly highlighted by other researchers (Puszka et al., 2016; Orchard et al., 2016; Lacasta Tintorer et al., 2018; Albrecht et al., 2017; Iacono et al., 2016). Users' attitudes towards risk-taking and change is another factor, similar results were described in former studies (Abd Ghani and Jaber, 2015; Bidmead and Marshall, 2016; Bishop et al., 2013; Hines et al., 2015; Bramley, Mangan and Conroy, 2018). Moreover, people's preference for their personal devices, bearing in mind that mobile health apps are sometimes use on one's personal phone, may also play a role in the adoption decision.

Cultural and social considerations, like people's negative perceptions on the usage of mobile devices at the workplace may hinder widespread adoption (Alajlani and Clarke, 2013; Farrell, 2016; McNally, Frey and Crossan, 2017); however, this is gradually changing and people are slowly accepting these tools as the new normal. This is a good example that shows the entanglement of the social and the material, as some may perceive the use of a specific technology or device (the smartphone) at work as a non-professional action. While mobile apps that can be used professionally are not new anymore, the stigma associated to the use of mobile devices at work still endures. The fact that some users may be concerned

with negative cultural perceptions of mobile devices use at the workplace, validates Leonardi's argument that "*culture tells us what something affords*", implying that the barriers and opportunities influencing technology adoption are the combined result of the entanglement among the material and social aspects of technology, and confirming Gherardi's notion that sociomateriality goes past material and social elements to also encompass the entanglement between cultural and natural factors (Leonardi, 2018; Gherardi, 2016).

Other social factors, like peer endorsement may also influence the intention of use. Participants explained that clinicians typically trust technologies that are endorsed by their colleagues or dependable medical associations, demonstrating again how the social and material factors begin to become entangled, as it becomes clear that adoption does not solely depend on the technological features and abilities but also on social elements like trusted endorsement. This suggests that in the absence of some social factors like endorsement or peer recommendations some efficacious and capable tools might go unnoticed.

From a material and technical perspective, usefulness was the most obvious factor; as reported in former studies, perceived usefulness was usually related to the time-saving and efficacy stemming from the tool's use (Varsi et al., 2015b; Saigi-Rubió, Jiménez-Zarco and Torrent-Sellens, 2016; Steinschaden, Petersson and Astrand, 2009), its favourable effect on the quality of care (Mueller et al., 2014; Anderson et al., 2017; Carlisle and Warren, 2013; de Souza et al., 2017), and the possible advantage for scientific evidence generation and research because of improved data availability (Kleinpell et al., 2016; L'Esperance and Perry, 2016). Perceived ease of use of the tool is a respectively significant factor that was extensively reported in similar research (Adenuga, Iahad and Miskon, 2017; Bello et al., 2017; Bhatta, Aryal and Ellingsen, 2015; de Vries et al., 2017).

IT factors like the system interoperability and integration of the tool with the healthcare organization's system were also emphasized by the participants, as this helps clinicians avoid the additional workload stemming from having to re-enter the same patient data once again in the hospital's system and what it could entail from documentation mistakes. Interoperability, which means that the possibility for the app to function correctly in relation to existing hospitals information systems not only as stand-alone, is a recognised challenge for health technologies and has been acknowledged in several other studies (El Amrani et al., 2017; Armstrong et al., 2011; Asua et al., 2012; Sharma and Clarke, 2014; Shaw et al., 2013; Lacasta Tintorer et al., 2018). As well as other technical problems such as login

issues or poor internet connectivity that may obstruct adoption (Kayyali et al., 2017; Molleda et al., 2017; O'Connor and Andrews, 2018; Orchard et al., 2016; Radhakrishnan et al., 2016).

The highly regulated nature of healthcare sheds light on some delicate topics like health data privacy and security. In the two cases that involve patient data in our study, this factor was perceived as a facilitator, as the two tools offer secure solutions for clinical data documentation and exchange, however, other researchers described this factors as a barrier in cases where data privacy and security is not warranted (Daniel et al., 2018; Loh, Flicker and Horner, 2009; El Amrani et al., 2017; Anderson et al., 2017; Bailey et al., 2017; Bidmead and Marshall, 2016; Holderried et al., 2018). Also, given the large amounts of data that these tools yield, participants raised some concerns around data management and interpretation, particularly as the ease of use of these tools significantly increases data capture and generation (Bramley, Mangan and Conroy, 2018; Brown et al., 2018; Chung et al., 2015; James et al., 2016; Öberg et al., 2017).

The tool's cost is also a vital factor; it can be considered a facilitator when the tool helps in saving costs by generating efficacies as described in similar readings (Armstrong et al., 2012; Avey and Hobbs, 2013; Ayatollahi et al., 2018; Catan et al., 2015); nevertheless, it can also be perceived as a barrier (Gagnon et al., 2016; Jimbo et al., 2013; Jungwirth and Haluza, n.d.) considering direct and indirect costs in relation to the creation of a proper infrastructure, like providing mobile devices across the healthcare organization to facilitate the tool's use. User experience and factors like the app's design, and content reliability and neutrality also impact clinicians' views of mHealth tools; for example, a cluttered design could discourage use. Factors such as app layout, interface, and culturally appropriate design, as well as the trustworthiness of the content were similarly reported in other studies (de Vries et al., 2017; Fairbrother et al., 2014; Gagnon et al., 2016; Jeon et al., 2014; Levine et al., 2014; Puszka et al., 2016; Radhakrishnan et al., 2016; Seto et al., 2012; Taylor and Coates, 2015; Taylor et al., 2016; Walker and Clendon, 2016).

5.1.3 Understanding how mHealth technology materializes in the organizing process

Let us now turn to the organizational and regulatory factors, to better understand implications for healthcare organizations, clinical workflow, and health policy aspects. Organizational and policy factors and implications were quite prominent in the three case studies, demonstrating that the interaction between technology users and the tools that they utilize produces the adoption patterns that we examine, and impacts the organizing process (the way people organize their daily work).

Participants agreed that mHealth use generated workflow advantages in many ways; for example, by facilitating location flexibility and consequently enhanced workflow fit, this is because mobile device enable clinicians to access the relevant data at the point of care, streamlining the patient's treatment process, a result that is aligned with what similar researchers concluded, that the tool's workflow fit boosts adoption (Bailey et al., 2017; Bello et al., 2017; Duhm et al., 2016). Additionally, better collaboration and transparency, as well as making clinicians' work easier were further workflow advantages, as participants observed that the tools made the inter-disciplinary cooperation easier and offered more transparency thanks to the enhanced documentation of health data, in accord with what other researchers have reported regarding health apps impact on collaboration (Ariens et al., 2017; Armstrong et al., 2012; Avey and Hobbs, 2013; Bello et al., 2017; Bramley, Mangan and Conroy, 2018; Brewster et al., 2014; Duhm et al., 2016), and streamlining workflow (Schneider et al., 2016; Williamson and Muckle, 2018; Zilliacus et al., 2010). The data availability resulting from the tools' use empowers clinicians, as they become instantly equipped with all the relevant information to make informed decisions; this was also reported in other studies (O'Connor and Andrews, 2018). Conversely, there are studies that stated that these tools might instead be viewed as a threat to healthcare providers' autonomy (Li and Cotton, 2018; Liu and Cheng, 2015; Ly et al., 2018; MacNeill et al., 2014). This, however, was not a concern amongst this study's participants.

Workflow disadvantages, on the other hand, were mainly caused by existing workload and resources shortages. Participants explained that the majority of healthcare practitioners are over-stretched and resources shortages may therefore hinder adoption, a point that has been described in former studies (Ariens et al., 2017; Bhatta, Aryal and Ellingsen, 2015; Bishop et al., 2013; Egerton et al., 2017; Ehrler et al., 2018). Additionally, the efficiencies resulting from these tools sometimes result in a higher overall workload, as clinicians gain the capacity to do more work in less time thanks to these app, resulting in an additional burden to the staff. The large scale introduction of these tools can also lead to changes in the roles and responsibilities, sometimes by eliminating some of the existing roles, or creating new ones that are more suited to the digital era, as observed in other studies (Molfenter et al., 2015; Penny, Bradford and Langbecker, 2018; Shaw et al., 2013; Sturesson and Groth, 2018). For example, we now start to see new roles such as 'clinical information officers' in some healthcare organizations to tackle not only the medical aspects but also the IT aspects like interoperability and software integration. Additionally, mHealth introduction may also require some changes of the hospital infrastructure to support its use. However, such changes in infrastructure can only be achievable if it is methodically

embraced by the healthcare organization, reinforcing the argument that the real influence of the materials and materiality on the organizing process may only be realized if something allows their materialization (Leonardi, 2018); meaning, that would only happen when the management enforces the infrastructure changes that support the implementation of a specific tool.

The inner or internal setting of the healthcare organization is also central for mHealth adoption. For example, a decision making-process that is too complicated or not clear enough can very well hinder or even prevent adoption, this issue was also raised in other cases (Bhatta, Aryal and Ellingsen, 2015; Muigg et al., 2018; Odeh et al., 2014; Öberg et al., 2017). Furthermore, many participants explained that it is often difficult to identify the staff members that should be responsible for deciding about bringing a new technological tool in their organization, and even when these people are identified the procedure can be quite difficult as the decision includes an inter-disciplinary group covering IT, medical informatics, finance, and medical. Given this complex decision making process, aspects such as the possibility to try and pilot the tool may support adoption as it allows the decision makers to test the new technology without risking the collapse of a broad rollout (Varsi et al., 2015b).

Providing continuous and proper training is also key, especially where the staff turn-over is high, as confirmed by other researchers (Armstrong et al., 2011; Asua et al., 2012; Dünnebeil et al., 2012; Duplaga, 2016; Gagnon et al., 2012b), similarly, the presence of proper reinforcement factors such as incentives can foster adoption. Moreover, organizations that desire to be seen as innovative have more acceptability of new technologies, this is aligned with other research that exhibited that factors such as institutional innovation and openness for change can foster adoption (Casey, Shaw and Swinglehurst, 2017; Saigí-Rubió, Torrent-Sellens and Jiménez-Zarco, 2014; Varsi et al., 2015b).

Participants also pinpointed some crucial patient related factors; for instance, tools that improve patient engagement and their safety are more accepted, as described in similar studies (Daniel et al., 2018; Hanley et al., 2013; L'Esperance and Perry, 2016; Miller et al., 2017). Equally, tools that improve patients' access to care also have higher chances of getting accepted and adopted (Armstrong et al., 2012; Avey and Hobbs, 2013; Bishop et al., 2013). Also, the external setting of the healthcare organization including health policies and regulations can influence adoption, participants explained that fostering technology acceptance and adoption in healthcare necessitates more clarity and simplification of the pertinent policies and regulations. Reimbursement and funding related regulations are of

particular importance (Anderson et al., 2017; Armstrong et al., 2011; Avey and Hobbs, 2013; Choi et al., 2018; Chung et al., 2015; Gagnon et al., 2016; Hickson et al., 2015), the absence or vagueness of such regulations can discourage adoption as they hinder the compensation of medical activities accomplished via mHealth.

User engagement in the development and implementation was found to be a key success factor by the research participants as was the case in similar studies (Brewster et al., 2014; Davis et al., 2014; Jarvis-Selinger et al., 2011; Lord et al., 2016; Molleda et al., 2017; Schmeer et al., 2016; Varsi et al., 2015b; Cox et al., 2017). This is usually a joint responsibility of the technology provider as well as the healthcare organization as they need to partner together in the development and implementation processes of the new tools. Incorporating users' feedback is not always easy though, essentially when the tool is completely integrated into the hospitals systems (which are mostly closed systems), obstructing the visibility of the tool's usability statistics from the tool's provider. The providers of the three tools studied in this research, however, successfully established different user input and feedback channels where they acquire users' opinions and medical informatics experts' input to ensure their tools remain relevant and useful. From their side, the participating clinicians showed strong interest in contributing to the development process of these new tools, as they expect an increase in digital roles for clinicians, not only in digital health start-ups but also in healthcare organizations.

5.2 Theoretical implications

From a theoretical perspective, the review of the most used framework in studying clinicians' mHealth adoption showed that several of the frequently used frameworks such as TAM offer an oversimplified set of aspects that need to be addressed in more detail and specificity. While it is sometimes argued that it is simplicity that makes these frameworks useful (Shachak et al., 2015), even in the healthcare context (Harst, Lantzsch and Scheibe, 2019; Holden and Karsh, 2010; Garavand et al., 2016), it is important to note that most of these models were not developed within a healthcare context and consequently overlook the complexity of its organizational and regulatory setting (Ammenwerth, 2019; Holden and Karsh, 2010; Rahimi et al., 2018). Additionally, frameworks such as TAM and UTAUT do not fully cover socio-organizational and cultural factors either (Ammenwerth, 2019; Rahimi et al., 2018). Another important point, is that many of the largely used models focus on tools that can be willingly used by individual users, unlike healthcare settings that usually involve an organizational-level resolution to implement specific tools that are released to all staff (Ammenwerth, 2019; Greenhalgh et al., 2017).

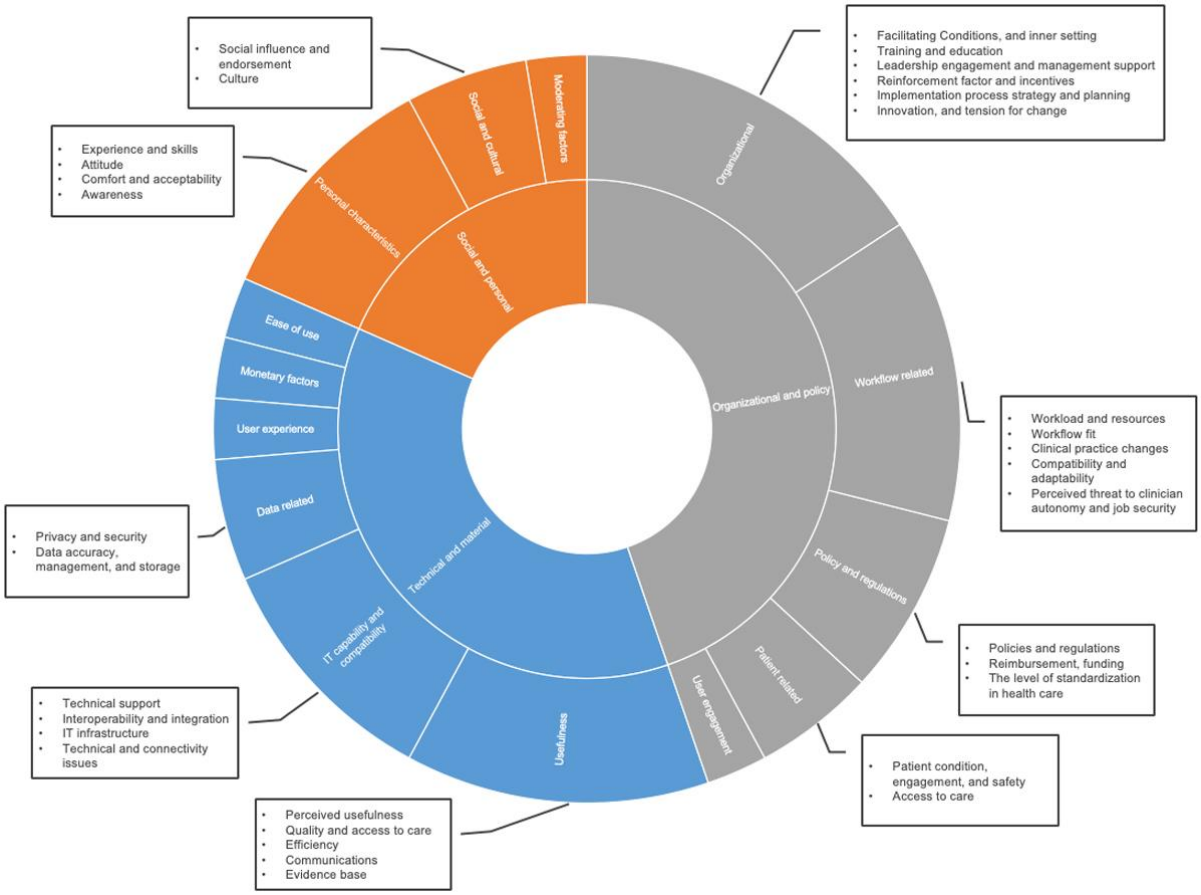
Researchers in most of the included papers expanded pre-existing technology acceptance models to be able to examine potentially significant additional factors; however, some academics have criticized such a method of subjectively adding constructs, as it can lead to an inconsistent use of established frameworks (Benbasat and Barki, 2007), highlighting the need for an aggregated framework that covers all these factors in one overview, and allows future researchers to have a more consistent approach to the topic, making sure that they do not overlook any of the important adoption factors.

Therefore, the researcher proposes a consolidated model that aggregates all the most used frameworks and complementing them with the additional factors that emerged from the gap analysis discussed in section 2.3.2, leading to a shift towards an extended framework that takes into account the complexity of the healthcare landscape, its highly regulated nature, and the interdependence between its different stakeholders, as well as the active role of clinicians in influencing how these new tools are being used in their work situation. Other researchers have similarly discussed that many of the broadly used frameworks adopt a technology-centred view focusing on the tool itself (Ammenwerth, 2019; Ward, 2013; Rahimi et al., 2018), and proposed a move to multi-dimensional models that go past usability to also encompass the surrounding organizational settings and implementation challenges (Shachak, Kuziemsky and Petersen, 2019; Ammenwerth, 2019; Ward, 2013; Sittig and Singh, 2010; Riley et al., 2011; Karsh, 2004).

Healthcare technology cannot be successfully adopted in isolation from the broader organizational context in which it is being used; therefore, we need to adopt theoretical frameworks that take into account implementation challenges in light of the complexity of the sociotechnical structure, and the interplay between the technical, social and organizational aspects. Accordingly, figure 21 represents a suggested consolidated framework that addresses the gaps in the most frequently used models, and complements them using a sociotechnical methodology that allows researchers to take into account all the contextual aspects, and, essentially, the interaction between them, when studying adoption. Figure 21 aggregates all the factors from the most used frameworks and contributes to knowledge by complementing them with the healthcare specific factors that emerged from the data, such as reimbursement; these complementary factors emerged from the gap's analysis discussed in section 2.3.2 and visualised in figure 9. This consolidated framework should help future researchers adopt a more consistent approach when studying the topic, and cover all the relevant factors in their studies related to mHealth adoption and implementation.

As shown in figure 21, the factors are categorized according to the sociotechnical approach to (technical and material), (social and personal), and (organizational and policy) factors.

Figure 21: Consolidated framework of the factors impacting clinicians' adoption of mHealth



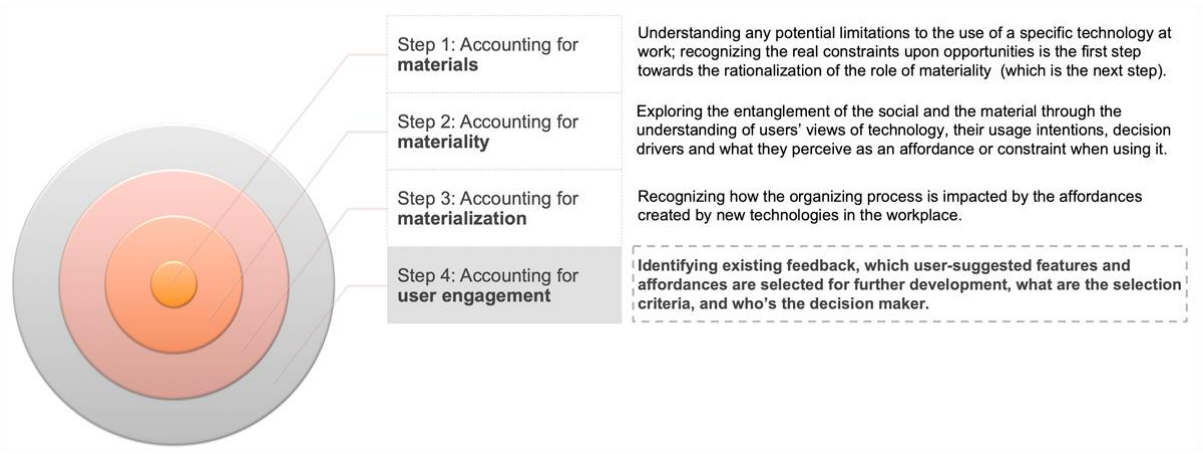
Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020b)

From a methodological guidelines' perspective, looking into the three steps in Leonardi's (2018) methodological guidance in contrast with the findings of the current study, the researcher suggests the addition of a fourth step to the guidance to better account for user engagement. This addition would enable researchers to reflect in more depth on the active role of the users in the adoption process. Embedding the users in the constant technology design and development processes warrants a better consideration of user-specific affordances; these can in turn be made more observable to other users and expand the potential of such tools to go beyond their technological features and have a higher impact on workflow and the process of organizing (how people organize their work) as perceived by the actual users.

To account for user engagement and ensuring that user-specific affordances can successfully make their way back to the design, researchers need to identify feedback loops established by the technology provider, better understand which user-suggested features are picked for development, and how they are chosen (based on which criteria), and also who the decision makers are. These questions can support the capture of any processes that trigger the active role of the users and the realization of affordances that could occur as shown in figure 22, it reflects the three first steps as defined by Leonardi (2018), then adds a fourth step with suggested ideas on how to best capture users' views and ensure that user engagement is imbedded in our research of technology adoption at the workplace. This expansion should help technology providers ensure the constant development of their tools in a way that keeps them useful and relevant based on active and constant user engagement.

It is important to remember though that including the users in the continuous development and testing of new tools can be challenging, particularly bearing in mind the extremely competitive ecosystem that mHealth technology providers are operating in, making them quite protective of their innovations out of fear of their competitors, a situation that often results in most of the new tools' design and testing being internally done without including any external stakeholders, including users (Oudshoorn, Rommes and Stienstra, 2004). This nevertheless, needs to change to allow the user-triggered affordances to make their way back to the design and to warrant that these new technologies will remain relevant in a continuously changing world. The desired balance between the recommended user engagement and the required confidentiality can be attained through some legal deals like non-disclosure agreements, advisory contracts, or the like.

Figure 22: Accounting for user engagement



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2019)

5.3 Practical recommendations

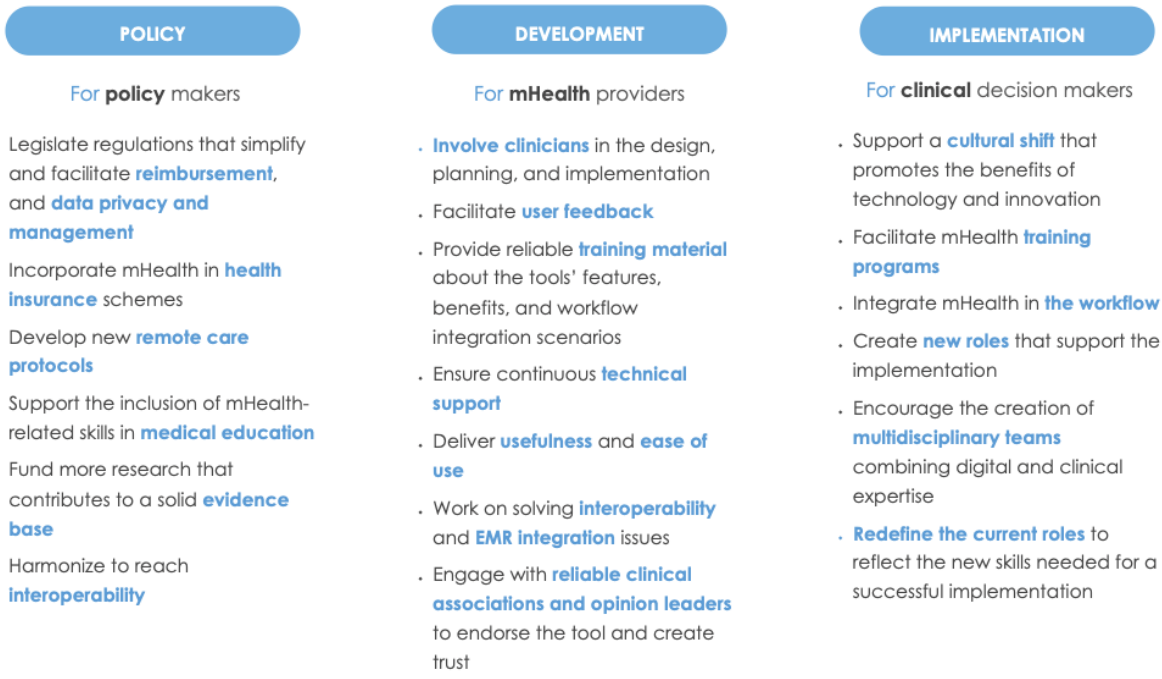
The findings of the multiple-case study are largely aligned with the results of the systematic literature review. The joint outcomes imply the importance of tackling specific technical, social, and organizational aspects so as to effectively encourage clinicians' mHealth adoption. The practical implications can be categorized in three clusters to define the needed actions from three major stakeholder groups: healthcare policy makers, mHealth technology providers, and clinical decision makers in the healthcare organizations, as visualized in figure 23.

Healthcare policy makers can positively impact mHealth adoption by properly addressing health data privacy and management concerns, and policies that streamline and enable the reimbursement of mHealth services. Tackle interoperability barriers by coordinating the fragmented healthcare landscape and streamlining technology would warrant a more effective implementation and integration of these tools. Upskill the healthcare workforce by integrating mHealth related capabilities in official health education to equip clinical staff with the essential skills to effectively run the tools. Integrate mHealth services in health insurance schemes may help address the cost issues and foster adoption for both patients and clinicians. Support scientific evidence generation through funding programs for studies that investigate mHealth benefits and added value. Help develop remote care protocols that can support clinicians streamline mHealth services and integrate them into their workflow.

mHealth technology providers should involve the users (clinicians and patients) more proactively in their development process, starting with design, testing, then planning and implementation, to ensure that their tool will fit well into routine care and clinical practice. Ensure the usefulness, ease of use, and technical support availability to enable a smooth day-to-day use of their tools. Encourage user feedback to ensure the tool's relevance and long-term sustainability. Deliver consistent training about their tools' various features and benefits, as well as an explanation of workflow integration scenarios in order to support clinicians with the tool's integration into their daily practice. Collaborate with the relevant stakeholders on solving EMR integration problems, to enable clinicians to harness the efficiency gains generated by these tools, and avoid any potential burden of double data entry when information systems are not properly integrated. Also, engage with dependable healthcare opinion leaders and medical associations to recommend the tool and help create trust that can encourage clinician adoption.

Clinical decision makers in healthcare organizations need to facilitate training programs that can help their staff acquire the essential skills for a successfully mHealth implementation. Encourage a cultural shift that fosters the value of innovation and technology to inspire their staff to embrace the new tools and change their conventional ways of working. Encourage the foundation of multidisciplinary groups that combine digital and medical capabilities, and redefine the existing roles to reflect the additional required skills. In a few cases, the creation of new roles might be necessary to enable an effective implementation. Moreover, plan for a proper integration of the new tools into the workflow to avoid that mHealth becomes more of burden to the clinical staff.

Figure 23: Practical recommendations



Source: initially published in (Jacob, Sanchez-Vazquez and Ivory, 2020a)

6 Conclusion

The findings of this multiple case study provided an in-depth understanding of the technical, social and organizational factors impacting clinicians' adoption of mHealth, highlighting that a tool's technical features and capabilities alone are not enough to determine its successful adoption. These findings reinforce what the researcher found in the systematic literature review, where it was apparent that some non-technical factors such as the social context, users' individual experience and skills, as well as organizational factors are crucial for the implementation and adoption of new technologies in healthcare. This confirms the suitability of the sociotechnical framework for studying healthcare technology adoption, as it goes beyond technology itself to encompass other contextual elements such as the social, individual, organizational, and policy factors.

The theoretical frameworks review, and the gap analysis allowed the researcher to clearly see the factors that are not considered by existing frequently used frameworks, allowing her to suggest an aggregated framework that takes all the relevant factors into account, and complements any gaps in existing models. This consolidated framework should help future researchers adopt a more consistent approach when studying the topic, and cover all the relevant factors in their studies related to mHealth adoption and implementation. Furthermore, the researcher suggests an expansion to Leonardi's methodological guidance to better incorporate the active role of users, the existing mechanisms to capture their experiences and input for each tool, and the processes that enable their prioritization and allow them to make their way back to the design. This expansion would enable the constant development of tools to help them stay relevant in an area that is constantly evolving.

From a practical perspective, the rich insights gained from the multiple case study, and complemented by the extensive literature review findings allowed the researcher to give some actionable recommendations that detail the necessary actions to be considered by the key stakeholders in order to foster mHealth adoption. The recommendations include specific actions for regulators and policy makers, technology providers, as well as clinical decision makers. These practical recommendations show that mHealth success requires close collaboration between the different players in the healthcare sector and cannot be achieved by technology providers alone, given the considerable importance of the regulatory landscape, as well as the organizational context.

The insights gained from this study could prove useful for policy makers, healthcare professionals, and technology providers. For the successful inclusion of mHealth adoption

factors it is crucially important to recognize the complexity of the healthcare ecosystem, its interdependencies, and highly regulated nature. There is a need for further research on this topic to test and validate the findings of this study and previous research, in order to facilitate a better understanding of the factors impacting clinicians' adoption of mHealth tools, and the implications for social and organizational practices.

6.1 Limitations and recommendations for future research

While this thesis contributes to the understanding of the social, organizational and technical factors impacting clinicians' adoption of mHealth, some limitations must be acknowledged. This research is limited to three specific mHealth tools, and focused on a specific geography through a certain timeframe. Moreover, the sample size is relatively small and excluded non-users because their recruitment showed to be very challenging. Furthermore, the constantly evolving nature of mHealth means that the context of the research might change very rapidly, requiring new research to update the findings and expand this work. Future researchers are highly encouraged to research the applicability of the findings in this thesis for different purposes and to adapt and extend them as needed.

Also, the literature review may not have included relevant studies that were not indexed in the searched databases, written in a language other than English, and grey literature searches that could have also enabled the identification of further significant insights. Additionally, it only considered published studies, and no further contacts were made with the papers' authors to obtain additional information or to validate the thematic analysis.

In order to address some of these limitations, future research should include other mHealth tools, in other locations, timeframes and settings. It would also be very pertinent to include some non-users to the participants mix to cover their opinions too. Future literature reviews could also include studies in languages other than English to have a better grasp of any inter-regional or inter-cultural differences, and to incorporate more studies in developed countries.

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Appendices

Appendix 1: interview guides

Interview guide – Clinicians v.1.3

Background Questions

1. Participant introduction

- Tell me about your role in the organization

- How long have you worked in healthcare?

- How long have you been using Mobile Health?

- How would you define your level of technical awareness

2. How would you define “Mobile Health” in one sentence?

Theme 1: “Accounting for materials”

3. Tell me about the app

- What are its main features?

- Are there any limitations in its features?

- If you would add one feature what would it be?

4. How did it help you and your patients?

Theme 2: “Accounting for materiality”

5. Tell me about what you wanted to achieve when you decided to use the app

6. What were the factors that influenced your decision to adopt the app?

- Which would you consider a barrier and which an opportunity?

7. Who made the decision to implement the app? And are there in assessment/selection criteria for such new technologies in your workplace?

Theme 3: “Accounting for materialization”

8. What influence did the app have on your work/the work of others (e.g Workflow)?

- Did it improve it?

- Was the previous practice better for some things?

9. Have these solutions led to changes in how the organization works, its rules or the use of other tools / technologies?

10. How have the uses of the app sustained, altered, or transformed the way that people interact in your organization?

11. In your opinion, what does the future hold for mHealth? And what roles will HCPs play in shaping this future?

Interview guide - Technology provider - v1.2

Background Questions

1. Participant introduction

- Tell me about your role in the organization

- How long have you worked in healthcare (or Healthcare Tech)?

- How long have you been working on Mobile Health apps?

- How would you define your level of technical awareness

2. How would you define “Mobile Health” in one sentence?

Theme 1: “Accounting for materials”

3. Tell me about your app

- What are its main features? What do the features do or not do?

- Are there any limitations in the features?

- If you would add one feature, what would it be?

4. How is it intended to help HCPs/patients?

Theme 2: “Accounting for materiality”

5. Tell me about what you wanted to achieve when you decided to create the app

6. Based on your experience with your customers: What are the factors that influence HCPs’ decision to adopt the app?

- Which would you consider a barrier and which an opportunity?

7. In your experience: Who usually makes the decision to implement mHealth?

- How widespread is its use?

- What do HCPs think?

Theme 3: “Accounting for materialization”

8. What do you think is the influence of the app on HCPs’ daily work?

- Did it improve it?

- Was the previous practice better for some things?

9. Has your app led – or could it potentially lead - to any changes in how healthcare organizations work, their rules, or the use of other tools / technologies?

10. How have – or potentially could - the use of your app sustained, altered, or transformed the way that people interact in healthcare organizations?

11. How do you ensure that your users are involved in the constant development of your solution (e.g. feedback channels…etc.).

12. In your opinion, what does the future hold for mHealth? And what will be the role(s) of HCPs in this development?

Interview guide – Medical informatics expert v.1.3

Background Questions

1. Participant introduction

- Tell me about your role in the organization

- How long have you worked in healthcare?

- How long have you been working with Mobile Health tools?

- How would you define your level of technical awareness, as a user (on a scale of 1 to 10)

2. How would you define “Mobile Health” in one sentence?

Theme 1: “Accounting for materials”

3. Tell me about the “app name”

- What are its main features?

- Are there any limitations in its features?

- If you would add one feature what would it be?

4. How did it help clinicians and patients in your clinic/hospital?

Theme 2: “Accounting for materiality”

5. Tell me about what you wanted to achieve when you decided to rollout the “app name” in your clinic/hospital

6. What were the factors that influenced your decision to adopt the “app name”?

- Which would you consider a barrier and which an opportunity?

7. Who made the decision to implement the “app name”? And are there in assessment/selection criteria for such new technologies in your workplace?

Theme 3: “Accounting for materialization”

8. What influence did the “app name” have on your work/the work of others (e.g Workflow)?

- Did it improve it?

- Was the previous practice better for some things?

9. Have these solutions led to changes in how the organization works, its rules or the use of other tools / technologies?

10. How have the uses of the app sustained, altered, or transformed the way that people interact in your organization?

11. In your opinion, what does the future hold for mHealth? And what roles will HCPs play in shaping this future?

Appendix 2: ethics approval

Anglia Ruskin University
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T: 0845 271 3333
Int: +44 (0)1223 363271
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Date 18 October 2017

Dear Student

Principal Investigator: Christine Jacob
FREP number: 01/07/2017
Project Title: Factors influencing Healthcare Professionals' adoption of Mobile Health Solution

I am pleased to inform you that your ethics application has been ***approved with minor amendments*** by the Faulty Research Ethics Panel (FREP) under the terms of Anglia Ruskin University's Research Ethics Policy.

Please action the points below and submit to your academic supervisor for them to review:

> ***Approved after revision as long as the PIS and PCF are issued to each participant early and with clarity. Please ensure you liaise closely with your supervisor as the project unfolds and keep him abreast of any concerns being raised by the project participants.***

Ethical approval is given for a period of 1 year for undergraduates/masters students from the date of this letter.

It is your responsibility to ensure that you comply with Anglia Ruskin University's Research Ethics Policy and the Code of Practice for Applying for Ethical Approval at Anglia Ruskin University, including the following.

- The procedure for submitting substantial amendments to the committee, should there be any changes to your research. You cannot implement these amendments until you have received approval from FREP for them.
- The procedure for reporting adverse events and incidents.
- The Data Protection Act (1998) or General Data Protection Requirement (25 May 2018) and any other legislation relevant to your research. You must also ensure that you are aware of any emerging legislation relating to your research and make any changes to your study (which you will need to obtain ethical approval for) to comply with this.
- Obtaining any further ethical approval required from the organisation or country (if not carrying out research in the UK) where you will be carrying the research out. Please ensure that you send the FREP copies of this documentation if required, prior to starting your research.
- Any laws of the country where you are carrying the research and obtaining any other approvals or permissions that are required.
- Any professional codes of conduct relating to research or requirements from your funding body (please note that for externally funded research, a Project Risk Assessment must have been carried out prior to starting the research).
- Completing a Risk Assessment (Health and Safety) if required and updating this annually or if any aspects of your study change which affect this.
- Notifying the FREP Secretary when your study has ended.

Please also note that your research may be subject to random monitoring.

Should you have any queries, please do not hesitate to contact me. I wish you the best of luck with your research.

Yours sincerely,

Kevin Roe
FREP Chair

Appendix 3: participant information sheet

Anglia Ruskin University

Version 2.2 - Jul 2019

Participant Information Sheet

The Research Project

1. **Title:** *Factors influencing Healthcare Professionals' Adoption of Mobile Health Solutions*

2. **Brief summary of research.**
Healthcare sectors are facing challenges with increasing costs, inconsistent patient care, and growing burden of chronic disease. Experts say that overcoming the challenges requires a transformation through a patient centric model, taking a more proactive and preventive approach that focuses on life quality not only on treating disease.
Mobile health is a notable area of transformation. Smartphones, in particular, are changing the rules of the game is so many ways. Healthcare experts explain that they are empowering Healthcare Professionals and patients by allowing them to access some diagnostic services and care outside of the healthcare setting.
The rise of healthcare apps that go beyond fitness to focus on disease and treatment management can potentially disrupt the current healthcare organizations structure by transforming the provider and patient power dynamics.
Despite this interest around the potential impact of mobile health, the academic research and clinical proof supporting its effectiveness is still limited. Former research by IMS health shows that in spite of the increase in the number and adoption of mHealth apps, more than half of those apps still have limited functionality.

   This research focuses on investigating the factors impacting the adoption of mobile health solutions by healthcare professionals, by better understanding their views of the potential of mobile health and barriers to its adoption.

3. **This study is part of** the researcher's PhD at Anglia Ruskin University, Cambridge, UK.

4. **Why have I been asked to participate?**
Due to your profile being identified as a renowned Digital Health expert, mHealth developer or healthcare professional using mHealth solutions.

5. **The main benefit** of taking part of the study that it may **lead to new knowledge** in the area of Mobile Health development and adoption.

6. You can **refuse to take part** of this study without giving a reason.

7. This study has received **ethical approval** from the ethics committee at Anglia Ruskin University.

8. **What will happen to the results of the study?**
The study results will be written up for the researcher's PhD, it may be published in academic journals and presented at conferences.

9. **Contact for further information** christine.jacob@pgr.anglia.ac.uk

Your Participation in the Research Project

1. **What will I be asked to do?**
   You will be invited to a face-to-face or remote interview (TC / hangout / Skype). The interview should last about 30-40 minutes and the researcher will ask you questions about the topic explained in the previous section.
   The researcher is interested in the personal views of the participants as users / experts / developers and not the organizations they are working for.
   You may be asked for a follow-up interview if appropriate and you are available.

2. **Your participation in the study will be anonymised.** Only the supervisors will have access to participants' data. No' personal or identifiable data be included in the dissemination of the results, which will be anonymised. Every effort will be made to ensure anonymity, but it may not be possible to guarantee complete anonymity. It is possible that participants may be identified by their colleagues or peers if not by the general public.

3. **Use of quotes** from participants in disseminating the research will be kept anonymous.

4. **Recording equipment** will be used to record the interview.

5. **You can withdraw from the study** and without giving a reason at any stage. To do so please e-mail me at christine.jacob@pgr.anglia.ac.uk. The last approximate time it will be possible to withdraw your data is 30th of October 2019, given it will not be possible once I have written the research up for the degree or published findings.

6. You do not have to answer any interview questions you do not wish to.

7. **Information that is collected from you** will be securely held. Personal identifiable information (e.g. consent forms) will be kept separately from the data. Participants will be assigned a study code number and identifying information stored separately from the data.

8. **Summary of research findings** will be shared with you by the end of the study, if you wish..

9. If you have **any complaints** about the study, please contact me at christine.jacob@pgr.anglia.ac.uk. You also have access to Anglia Ruskin University's complaints office. Email address: complaints@anglia.ac.uk Postal address: Office of the Secretary and Clerk, Anglia Ruskin University, Bishop Hall Lane, Chelmsford, Essex, CM1 1SQ.

Date 07.19
V2.2

Appendix 4: participant consent form

Participant Consent Form Version 2.2 - Jul 2019

Name of participant: ……..

Participant Identification Number for this study: ……

Title of the project:
Factors influencing Healthcare Professionals' adoption of Mobile Health Solutions

Main investigator and contact details: Christine Jacob christine.jacob@pgr.anglia.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet (**Version 2.2 - Jul 2019**) for the study. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

2. I understand that I am free to withdraw from the research at any time until October 2019, without giving a reason.

3. I am free to ask any questions at any time before and during the study.

4 I understand what will happen to the data collected from me for the research.

5. I have been provided with a copy of this form and the Participant Information Sheet **Version 2.2 - Jul 2019**.

6. I understand that non-identifiable quotes from me could be used in the dissemination of the research, and I am expressing my personal views not the organization I work for.

7. I understand that the interview will be recorded.

Data Protection: I agree to the University[1] processing personal data, which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me*

Name of participant (print)……Signed……..…..Date……
Name of person
taking the consent (print)……Signed…….. Date……

I WISH TO WITHDRAW FROM THIS STUDY.

If you wish to withdraw from the research, please speak to the researcher or email them at christine.jacob@pgr.anglia.ac.uk stating the title of the research.
You do not have to give a reason for why you would like to withdraw.
Please let the researcher know whether you are/are not happy for them to use any data from you collected to date in the write up and dissemination of the research.

[1] "The University" includes Anglia Ruskin University and its Associate Colleges.